Informational Technology and Its Impact on American Education

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Informational Technology and Its Impact on American Education

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Foreword

Over the last decade, American education has come to face a number of new demands that must be met with limited resources. Many of these new demands arise from the rising dependence of our society on technology as a basis for domestic economic growth, international competitiveness, ~~and national~~ security. In October 1980, the House Committee on Education and Labor, its Subcommittee on Special Education, and the Subcommittee on Science, Research, and Technology of the House Committee on Science and Technology asked OTA to examine the extent to which information technology could serve American needs for education and training.

No subcom on Sp. Education

This report documents two basic sets of conclusions:

1. The so-called *information revolution,* driven by rapid advances in communication and computer technology, is profoundly affecting American education. It is changing the nature of what needs to be learned, who needs to learn it, who will provide it, and how it will be provided and paid for.
2. Information technology can potentially improve and enrich the educational services that traditional educational institutions provide, distribute education and training into new environments such as the home and office, reach new clients such as handicapped or homebound persons, and teach job-related skills in the use of technology.

The OTA report provides an overview of the issues relating to the educational applications of the new information technologies. It examines both the demands that the information revolution will make on education and the opportunities afforded by the new information technologies to meet those demands. Rather than focusing on a single technology, it examines a wide variety of new information products and services such as those based on the combined capabilities of computers, telecommunications systems, and video technologies. Similarly, the report surveys a broad range of educational providers, and examines how the application of information technologies may affect their abilities to provide education and their respective educational roles.

OTA acknowledges with thanks and appreciation the advice and counsel of the panel members, contractors, other agencies of Government, and individual participants who helped bring the study to completion.

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Chapter 1
Summary

Information technology is proving to be invaluable to people of all ages

Chapter 1

Summary

Modern society is undergoing profound technological and social changes brought about by what has been called the information revolution. This revolution is characterized by explosive developments in electronic *information technologies* and by their integration into complex information systems that span the globe. The impacts of this revolution affect individuals, institutions, and governments—altering what they do, how they do it, and how they relate to one another.

If individuals are to thrive economically and socially in a world that will be shaped, to a large degree, by these technological developments, they must adapt through education and training. Already there is evidence of demands for new types of education and training, and of new institutions emerging to fill these demands. The historical relationship between education and Government will be affected by the role that Government plays in enabling educational institutions to respond to the changes created by these technologies.

Background

Historically, the Federal Government's interest in educational technology has been sporadic—rising as some promising new technology appeared and falling as that technology failed to achieve its promise. Attention was focused, moreover, on the technology itself and not on the broader educational environment in which it was to be used. In the late 1960's, for example, the Federal Government funded a number of research and development (R&D) projects in the use of computer-assisted instruction (CAI). Interest in the projects waned, however, given the high costs of hardware and curricula and the failure to integrate computer-based teaching methods into the institutional structure of the school.

Over the last decade, Federal funding for R&D in educational information technology has dropped precipitously. At the same time, development and applications of information technology have advanced rapidly in many sectors. Public schools, beset by problems that such technology might mitigate, have lagged behind in adapting to technological changes. In view of this situation, OTA was asked in October 1980 to reexamine the potential role of new information technology in education.

The assessment was initiated at the request of: 1) the Subcommittee on Select Education of the House Committee on Education and Labor; and 2) the House Subcommittee on Science, Research, and Technology of the Committee on Science and Technology.

This report examines both the demands the information revolution will make on education and the opportunities afforded to respond to those demands. Included in its scope are a survey of the major providers of education and training, both traditional and new, and an examination of their changing roles. The full range of new information products and services rather than any single technology is examined, since the major impact on education will most likely stem from the integration of these technologies into instructional systems.

For this report OTA has defined *education* to include programs provided through a variety of institutions and in a variety of settings, including public schools; private, nonprofit institutions that operate on the elementary, secondary, and postsecondary levels; proprietary schools; training and education by industry and labor unions; instruction through the military; and services provided through libraries and museums or delivered directly to the home. *Information technology* is defined to include communication systems such as direct broadcast satellite, two-way interactive cable, low-power broadcasting, computers (including personal computers and the new hand-held computers), and television (including video disks and video tape cassettes).

The assessment was premised on three initial observations and assumptions:

- The United States is undergoing an information revolution, as documented in an OTA assessment, *Computer-Based National Information Systems.*
- There is a public perception that the public schools are "in trouble," and are not responding well to the normal educational demands being placed on them. Public schools in many parts of the country are faced with severe economic problems in the form of rapidly rising costs and reduced taxpayer support. These pressures are forcing a new search for ways to improve the productivity and effectiveness of schooling.
- A host of new information technology products and services that appeared capable of fulfilling the educational promises anticipated earlier are entering the marketplace with affordably low cost and easy accessibility.

Findings

OTA found that the real situation is far more complex than assumed above. In summary, the assessment's findings are:

- The growing use of information technology throughout society is creating major new demands for education and training in the United States and is increasing the potential economic and social penalty for not responding to those demands.
- The information revolution is creating new stresses on many societal institutions, particularly those such as public schools and libraries that traditionally have borne the major responsibility for providing education and other public information services.
- Information technology is already beginning to play an important role in providing education and training in some sectors.
- Information technology holds significant promise as a mechanism for responding to the education and training needs of society, and it will likely become a major vehicle for doing so in the next few decades.
- Much remains to be learned about the educational and psychological effects of technological approaches to instruction. Not enough experience has been gained with the new information technology to determine completely how that technol-

ogy can most benefit learners or to predict possible negative effects of its use. Given this insufficient experience, caution should be exercised in undertaking any major national effort, whether federally inspired or not, to introduce these new technologies into education.

The Information Society

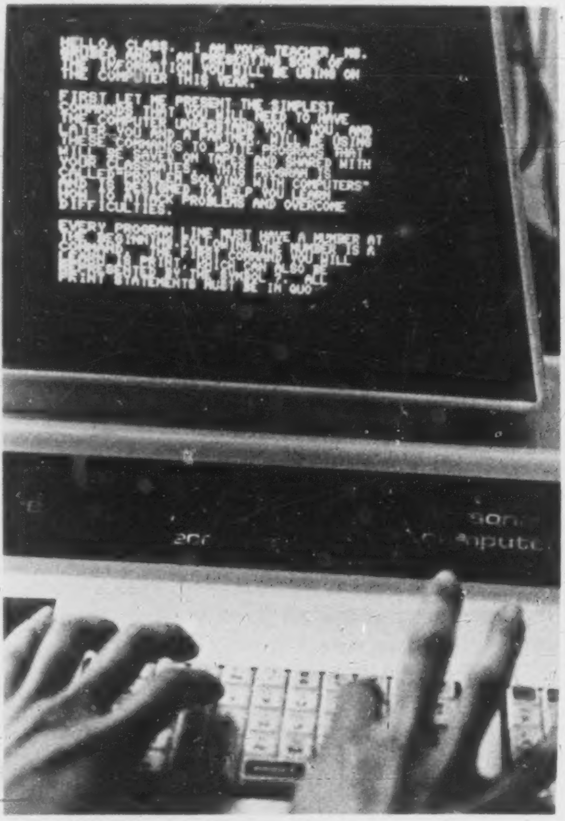
Role of Information

For the foreseeable future, information technology will continue to undergo revolutionary changes. The microprocessor—an inexpensive, mass-produced computer on a chip—will become ubiquitous in the home and office—not only in the easily identifiable form of the personal computer or word processor, but also as a component of numerous other products, from automobiles to washing machines and thermostats. High-speed, low-cost communication links will be available in such forms as two-way interactive cable, direct broadcast from satellites, and computer-enhanced telephone networks. New video technologies such as video disks and high-resolution television will be available. These technologies will be integrated to form new and unexpected types of information products and services, such as videotex and on-line information retrieval systems that can be provided over telephone or air waves directly to the home.

It is impossible to predict which of these technologies and services will succeed in the competition for consumer dollars, or which will appeal to particular markets. It is, however, reasonable to conclude that they will radically affect many aspects of the way society generates, obtains, uses, and disseminates information in work and leisure.

The growing importance of information itself drives and is driven by these rapid technological changes. Until a few decades ago, the information industry—that industry directly involved with producing and selling information and information technology—was relatively small in economic terms. It is now becoming a major component of the U.S. economy. While most economists still talk about the traditional economic sectors—extractive, manufacturing, and service—some now have begun to define and explore a fourth, the information sector. One analysis has shown that this new sector, if defined broadly, already accounts for over 60 percent of the economic activity of the United States.

Many firms involved directly with information are large and growing. Two of the largest corporations in the world, AT&T and IBM, principally manufacture information products



Personal-type computers are used for instruction in many classrooms throughout the Nation and provide information services. Moreover, business in general is beginning to treat information as a factor of production that takes its place beside the conventional factors of land, labor, and capital. In addition, the Government is beginning to treat information as an important element of national security. While defense officials have always been concerned about the disclosure of military information—such as troop movements or weapons design—they are now also concerned about the international leakage of more general U.S. scientific and technical information that other countries could conceivably use to pursue economic or military goals that are in contrast to our own.

In addition to serving as an economic good, access to information is becoming increasingly important for individuals to function in society effectively as citizens, consumers, and participants in political processes. Relations with government at all levels are becoming more complex—whether they involve dealing with the Internal Revenue Service, applying for social benefits and services, or seeking protection from real or perceived bureaucratic abuse. Individuals are confronted with the need to evaluate more sophisticated choices and to understand their rights and responsibilities under the laws and regulations intended to protect them in the marketplace.

Information Technologies

The rapid evolution of the following technologies in the last few decades has shaped the information revolution:

Cable.—Cable systems—wherein data and programs are transmitted over a wire rather than through airwaves—are growing rapidly. The newer systems offer more channels, and some offer two-way communication.

Satellite Communication.—Satellites have stimulated development of new types of television networks to serve cable subscribers and earth station owners with specialized programing.

Digital Telephone Network.—The shift to digital transmission will allow telephone lines to carry more information at higher speed and with greater accuracy, providing better linkage of information between computer terminals.

Broadcast Technologies.—Some distribution technologies in the entertainment market may also have important potential educational uses. For one, the *direct broadcast satellite* can transmit a program directly to a home or office, bypassing a cable system. For another, *low-power stations,* which restrict transmission to a limited geographical range, provide a low entry cost to licensees and are subject to less regulation than are traditional broadcast stations.

Computers.—The design and uses of computers have advanced to the point where there is now a mass consumer market for computers and computer software. Moreover, networks that link privately owned computers have expanded access to information. *Desktop computers* are becoming more common in the home, the small business, and formal educational settings. The use of *hand-held computers,* cheaper and more portable than desktop computers, has also increased. Along with computer development have come advances in the interface between humans and computers—input/output technology. Input technology is the process of putting information into the computer—either by typing it, speaking to the computer, or showing the computer pictures. Developments in output technology are occurring in the areas of low-cost printers, graphics (particularly color graphics), and voice.

Storage Technology.—Data programs are stored on a variety of media for use in the computer: silicon chips, floppy disks, and hard disks. Improvements are being made in such technology for both large and small computers.

Video Technology.—Significant developments in several areas of video technology are likely in this decade. *Video cassette recorders* are already important consumer devices. The *filmless camera*, which combines video and computer technology to "write" a picture on a very small, reusable floppy disk, may soon be available.

Video Disks.—Resembling a phonograph record, a disk that stores television programing is of considerable interest to educators. It is durable, inexpensive to produce, and capable of storing a large amount of data and programs.

Information Services.—Several of the aforementioned information technologies are now being integrated to provide new types of services. For example, several countries now use the existing television broadcast medium to bring information services to homes and offices. Using a *teletext* system, the user can select a page for special viewing as it is transmitted in segments over the air. In a videotex system the user can preselect a page from the central system for immediate viewing. Closely related to videotex are the *information networks* that provide owners of desktop computers and terminals with access to computer and data services and to one another over communication networks. Through *electronic conferencing,* geographically separated individuals can participate in meetings. Variations include *audio conferencing,* which uses telephone lines; *video conferencing,* which supplements the voice connection with television images; and *computer conferencing,* which involves transmitting messages through a central computer that then distributes them as requested.

Impacts on Institutions

Impacts from the information revolution are being felt by government at all levels and by the military, industry, labor unions, and nonprofit service institutions. Traditional services provided by these institutions now overlap in new ways and offer a wide variety of new services based on information technology. For example, firms as diverse as investment houses and retail stores now compete with banks by providing a variety of financial services. Banks, on the other hand, are beginning to compete with computer service bureaus in providing more general on-line information services to businesses and homes.

The U.S. Postal Service, along with Congress and a variety of Federal executive and regulatory agencies, is considering the degree to which it should compete with private telecommunications firms in the provision of electronic mail services. Large computer firms such as IBM are moving toward direct competition with traditional telecommunication common carriers such as AT&T for the provision of information. Telephone companies may offer "electronic yellow pages" that could rival the classified advertising business of newspapers.

Those institutions principally concerned with the collection, storage, or transfer of information will feel the greatest effects. They include both private sector firms—in fields such as publishing, entertainment, and communications—and public or nonprofit organizations such as libraries, museums, and schools. How they handle their product—information—may differ from the handling of tangible goods by other institutions because information has characteristics that differentiate it from tangible goods. For example, information can be reproduced easily and relatively inexpensively. It can be transported instantly worldwide and presumably can be transferred without affecting its original ownership. Thus, copyright or other forms of protection for intellectual property—data bases, programs, or chip designs—is important to the growth of the information industry.

While the business of selling information has always existed in some form—e.g., book publishing, newspapers, or broadcasting—the growth of this sector and its movement into electronic forms of publishing will create conflicts with traditional societal attitudes about information. The concept of information as a public good whose free exchange is basic to the functioning of society is inherent in the first amendment to the Constitution and underlies the establishment of public libraries and schools. This concept conflicts with the market view of information, which recognizes that there are inherent costs in the provision of information. Adopting new information technologies will entail extra costs that must be borne somehow by the users of those technologies.

The conflict between the view of information as a market good and the view of it as a "public good" affects public institutions in a number of ways. Public nonprofit institutions find themselves increasingly in competition with private profitmaking firms that offer the same or similar services. Institutions such as libraries, schools, and museums are beginning to feel pressure to incorporate both nonprofit and income-generating offerings in their own mix of services. To the extent that previously free or very low-cost and widely available information services such as education move into the private marketplace, access to them may become limited, either because of their cost or because of their restricted technological availability. Periodicals previously available at newsstands, for example, may be available in the future only via computer or video disk.

New Needs for Education and Training

The information revolution places new demands on individuals, changing what they must know and what skills they must have to participate fully in modern society. It may also be increasing the social and economic prices that will be paid by those who do not adapt to technological changes. For instance, spurred by increasing domestic and international economic competition, U.S. industry is expected to adopt computer-based automation in a major way. Computer-aided design, robotics, and other new computer-based manufacturing technologies will, within the next decade, transform the way goods are manufactured. Automation will not be restricted to the factory, however. Office automation will, according to some, have an even more revolutionary effect on management and on clerical work in business. Over the longer term, even the service professions, such as law and medicine, will be transformed.

While some sociologists suggest that the effect will be to "deskill" labor by lowering the skill requirements for workers, more anticipate that a greater premium will be placed on literacy, particularly technological and information literacy. The latter argue that an increasing number of jobs will be in the information sector or will require the use of information systems. Moreover, new forms of production and information handling will create new jobs requiring new skills. Vocational education and industrial training programs will be needed to teach the skills for jobs such as robot maintenance or word processing.

An advanced information society will place a premium on skills oriented toward the creation of new knowledge and the design of new technologies. Thus, while there is some current debate about a possible surplus of college graduates, generally speaking many experts see a growing gap between the demand and supply of graduates in engineering and science, and particularly in computer engineering and science.

A key element in all of these educational needs is that they will constantly change. In a rapidly advancing technological society, it is unlikely that the skills and information base needed for initial employment will be those needed for the same job a few years later. *Lifelong retraining is expected to become the norm for many people.*

Case Studies on Information Technology

In addition to using existing information for this assessment, OTA undertook case studies designed to gain insights into the successful application of information technology in education. Accordingly, OTA examined well-established programs in public school systems, industries, libraries, museums, the military, special education, and direct to the home markets nationwide. These case studies are presented in the appendix. Many of the findings presented in this assessment reflect observations made in these studies. *The most important of these observations is that information technologies can be most effectively applied to tasks when they are well integrated in their institutional environments.*

Potential Technological Solutions

OTA found little evidence of current hardware limitations that would limit the applicability of technology to education and, hence, call for major research efforts. Continuing research in the general fields of computer science and engineering, coupled with innovative private sector development will provide the necessary hardware base. The only exception is the area of technology for the handicapped, where it is not clear that the opportunities for developing specialized technology could be met without some Federal support for R&D. There does appear to be a need, however, for R&D focused on developing new techniques and tools for software development, human/machine interface, and improving the understanding of cognitive learning processes.

If properly employed, information technology has certain characteristics that suggest it will be invaluable for education. For one, information technology may be the only feasible way to supplement teaching capability in schools faced with reduced teaching staffs and larger class sizes. For another, information technology is capable of distributing education and training, both geographically and over time. Services can be provided in the home, at work, in a hospital, or in any other location where and when they may be needed.

Many of the electronic media, such as video disks or microcomputers, allow learners to use them at their convenience, instead of being locked into specifically scheduled times. Computer-based analysis, combined with a flexible, adaptive instructional system could diagnose and immediately respond to differences in learning strategies among students and, hence, could be more educationally effective. Finally, much work has been done on using information technology to improve the ability of foreign students and the physically and mentally handicapped to communicate.

Some experts suggest that the use of computers by students teaches them new ways of thinking and new ways of solving problems that may be more appropriate in an information age. They suggest that a generation that grows up with computers will have a significant intellectual advantage over one that does not. Many educators criticize such a view as being too technology-centered. At the very least one can predict, however, that computer and computer-based information services will be ubiquitous by the next century, and that learning how to use them effectively is a basic skill that will be required for many and perhaps most jobs. (In response to this view of future skill requirements, many schools have placed a high priority on computer literacy as the first instructional use of the computer.)

Although experience with educational technologies has demonstrated that they offer a variety of potential benefits, it has also demonstrated that technology cannot, by itself, provide solutions to all educational problems, nor should it be imposed on an educational system without sensitivity to institutional and societal barriers that could prevent the realization of educational benefits. These barriers include:

Institutional Barriers.—New educational technology must be designed for ease of integration into the schools and other educational institutions that will use it. Some adaptations of curricula, schedules, and classroom organization will be needed, but the changes are not likely to be extreme.

Teacher Training.—Widespread use of technology in the classroom will require that teachers be trained both in its use and in the production of good curriculum materials. Too few teachers are so qualified today. Schools maintain that they are already faced with a shortage of qualified science and mathematics teachers (those most likely to lead the way in computer-based education). Furthermore, there is little evidence that most of the teacher training colleges in the United States are providing adequate instruction to new teachers in the use of information technology.

Lack of Adequate Software.—OTA found general widespread agreement that, with few exceptions, the quality of educational software—curriculum material designed for educational technology—now available was, in general, not very good. Curriculum providers do not yet use the new media to full advantage for several reasons. In the first place, many of the technologies are still new. It takes time to learn how to use them, and the early attempts suffer from this learning process. Second, production of high-quality educational software is expensive. Some large firms that have the necessary capital to produce educational software hesitate to risk developmental money in a relatively new and uncertain market.

Third, the programers and curriculum experts qualified to produce educational software are in short supply. Finally, some firms cite the lack of adequate property protection—e.g., copyright, patents—for their information products as a barrier to investment in development.

Skepticism About Long-Term Effects.—Some educators are seriously concerned that the long-term effects on learning of substituting technology for traditional teaching methods are not sufficiently understood. While acknowledging that computers or other technologies may have some limited utility in the classroom for drill and practice, or for instruction in computer literacy, they fear that any widespread adoption of technology for education could have deleterious effects on the overall quality of learning.

Cost.—Even though the cost of computer hardware and communication services is dropping, investment in educational technology still represents a substantial commitment by financially pressed schools. Costs of software are likely to remain high until a large market develops over which providers can write off developmental costs. In some cases the cost of information products and services may be passed on to users for the first time.

Policy Issues and Options

Issues

The impact of information technology on education will confront Congress with a number of important policy decisions in several areas:

- *Education and training for economic growth:* OTA found that trends in automation and the growth of the information sector of the economy will probably present the United States with severe manpower training problems over the next decade. These will include a persistent shortage of highly trained computer scientists, engineers, and other specialists; a need for retraining workers displaced by factory and office automation; and a need for a more technologically literate work force. Congress must decide what Federal response to these national needs would be both appropriate and effective.
- *Redressing inequities:* In both the OTA study on national information systems and in this assessment, OTA found concern that a significant social, economic, and political gap could develop between those who do and those who do not have access to, and the ability to use, information systems. People who cannot make effective use of information technology may find themselves unable to deal effectively with their government and to obtain and hold a job. Both social and economic concerns may motivate Congress to take action to improve literacy in American society.
- *New institutional roles:* OTA found that many public educational institutions are

under severe strain, to the extent that many question their survival—at least in their current form. Actions directly related to the use of information technology could also have important impacts on these public educational institutions, both by enhancing their productivity and by helping them offer a modern, computer- and communication-based curriculum. Although the States have primary responsibility for control of the public schools, decisions and policies set at the Federal level have influenced the nature of public education and will continue to do so.

Options for Federal Action

Assuming that Congress decides there is a significant need for Federal action to address these issues, there are a number of possible actions it could take.

- **Direct Intervention.**—Congress could take action to increase and improve the use of information technology in education. Most of the following options would principally affect the schools. A few would have a broader effect on the provision of education and training in other institutions.
  - —*Provide tax incentives for donations of computers and other information technology:* H.R. 5573 and S. 2281 are examples of such initiatives. They are intended to accelerate the rate at which schools install computer hardware and to respond to possible inequities in the abilities of school districts to direct funds to equipment acquisition. However, some experts have noted that the personal computer industry is on the verge of moving to a new generation of more powerful machines that may have much greater potential for educational application on a more sophisticated level. Donations of older equipment could freeze the schools into dependency on obsolescent systems. Moreover, such incentives do not address problems such as the need for software, teacher training, or institutional barriers to effective use.
  - —*Subsidize software development:* OTA found that the most-often cited barrier to current educational use of technology was the lack of adequate educational software. There may be a role for the Government in reducing the risks software producers currently see that inhibit major investment in quality courseware (educational software). Many of the existing successful packages, such as the Sesame Street programs for television and the PLATO computer-aided instruction system, were developed with partial Federal support. On the other hand, good software may be forthcoming if the producers see a sufficient quantity of hardware in the schools to provide them with a viable market.
  - —*Directly fund technology acquisition by the schools:* The Federal Government could directly underwrite the acquisition of hardware and software by the schools. Such a program would create a market for educational products that would attract producers, and it would accelerate the introduction of technology into the schools. On the other hand, such an approach may promote premature and unwise purchases of technology by schools that are unprepared to use the technology effectively. It is also counter to some current trends and attitudes in Congress concerning the proper Federal role in education.
  - —*Provide support activities:* The Federal Government could assume a leadership role in encouraging the educational system to make more effective use of information technology by funding demonstration projects, teacher-training programs, and the development of institutions for exchanging information about successful implementations. OTA found evidence of a high degree of interest and motivation by both schools and parents that could be more effectively channeled with appropriate Federal leadership. Such a program would not address the financial limitations that currently prevent many institutions from acquiring technology and software.
- **Adapt a General Education Policy.**—Congress is considering various forms of education-related legislation that may affect, and

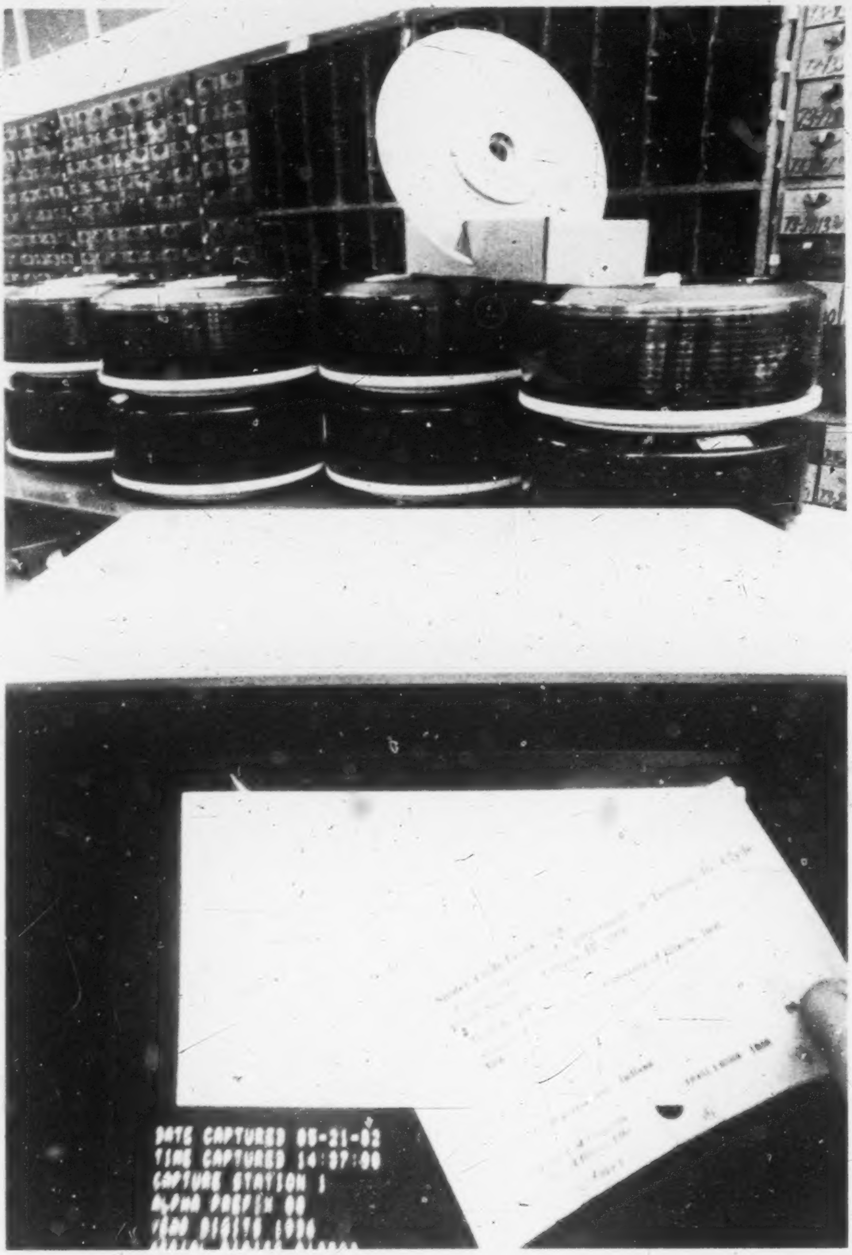
in turn may be affected by, the new informational needs of society. Examples are bills concerning vocational education, veterans' education, education for the handicapped, and foreign language instruction. Such legislation, if drafted with the intent to do so, could encourage the development of more effective and economical technological alternatives to current programs.

- **Support R&D.**—Federal civilian agency support of R&D in educational technology has decreased substantially over the last decade. OTA found that, to make the most effective use of technology, there was a need for R&D in learning strategies and cognitive development, methods for the production of effective and economical curricular software, and the long-term psychological and cognitive impacts of technology-based education. Congress could consider policies to: 1) directly support R&D in these areas, 2) encourage private sector investment from both foundations and industry, or 3) encourage a combination of both by using Federal funding to leverage private investment.
- **Elimination of Unintended Regulatory Barriers.**—Some legislation and regulation not specifically directed at education may create barriers to the effective application of educational technology. Telecommunication regulation, for example, can affect the cost of technology, access to communication channels, and the institutional structure of education providers.

Moreover, protection of intellectual property, principally copyright law, was identified as a major determinant of the willingness of industry to invest in educational software. The current state of the law was seen by many industry experts as inadequate and, hence, as creating a barrier to the development of novel and innovative software. However, to the extent that such a barrier does exist, it is not clear whether its removal lies in new legislation or in the gradual development of legal precedent in the courts.

Chapter 2

The United States as an Information Society



To facilitate the storage and accessibility of an increased amount of information, the main card catalog at the Library of Congress is being converted to computer records. Thousands of entries are stored on the correctable magnetic disks. Twenty of these disk packs are entered into one optical disk (seen atop the magnetic packs for permanent record). These optical disks can be randomly accessed and are connected to a printer. They contain an amount of information that was formerly held in 144 card drawers

Chapter 2

The United States as an Information Society

All societies depend to some extent on information—to conduct trade, to govern their society, and to transmit culture and social mores. Because of this, past inventions such as writing, arithmetic, and the printing press have stimulated profound changes. Similarly, development of new information technologies will also deeply effect present-day society. Many of these effects will be in the realm of education.

Findings[1]

- The United States has become an information society, dependent on the creation, use, and communication of information for its economic and social well-being.
- Computer, data communication, and video technologies have become a large and essential element of U.S. society, central to the handling of information by individuals and organizations.
- In the past, information technology inventions such as the telephone have fundamentally altered social institutions and individual behavior; thus, it is reasonable to expect that current and future innovative developments will have corresponding effects, particularly on activities such as education that depend on information.
- Trends in the use of information technology are creating new demands on education in terms of who is to be educated, when education occurs, what is to be taught, how it is to be taught, and what it is to cost.

In a complex, highly technological society, demands grow for quick access to and use of large amounts of information in order to control economic, social, and political processes. It has been suggested that the creation, use, and communication of information are essential components of the infrastructure of a "postindustrial society" such as that of the United States.[2] As a consequence, many societal functions are completely dependent on information technology. For example:

- Airlines use computer networks to control passenger reservations, schedule equipment usage and maintenance, and prepare flight plans; and the Federal Government uses a large computer-based system to control the resulting air traffic.[3]
- Banks and other financial institutions rely completely on computers and worldwide communication networks for managing accounts, clearing checks, exchanging funds, and providing a wide variety of new financial services.[4]
- Major Government agencies, such as the Internal Revenue Service and the Social Security Administration, require large, automated information systems to handle the accounts of hundreds of millions of clients.

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[1] Much of the information presented in this chapter is based on OTA's previous study, *Computer-Based National Information Systems: Technology and Public Policy Issues*, OTA-CIT-146 (Washington, D.C.: U.S. Congress, Office of Technology Assessment, September 1981).

[2] D. Bell, *The Coming of Post-Industrial Society* (New York: Basic Books, 1973).

[3] *Airport and Air Traffic Control System*, OTA-STI-175 (Washington, D.C.: U.S. Congress, Office of Technology Assessment, January 1982).

[4] *Selected Electronic Funds Transfer Issues: Privacy, Security, and Equity—Background Paper*, OTA-BP-CIT-12 (Washington, D.C.: U.S. Congress, Office of Technology Assessment, March 1982).

- The operation of national defense depends on complex computer-communication systems, both for day-to-day management of the military establishment and for command and control of modern sophisticated weaponry.
- Multinational corporations depend on international networks of computers for such applications as production control, management, and financial administration.

Since these and other users of information in the United States are relying increasingly on sophisticated computer and communication systems, it is reasonable to anticipate that information technology will have significant effects on the structure and operation of most of our social institutions. Furthermore, institutions and social processes such as education, which are so dependent on the communication and use of information, will be most affected.

The basic goals of education are the communication of knowledge and skills, the transmission of culture, and the instilling of basic literacy.* Since all of these require that education be closely linked to information processes, education will be deeply affected, both in content and form, by the technological revolution.

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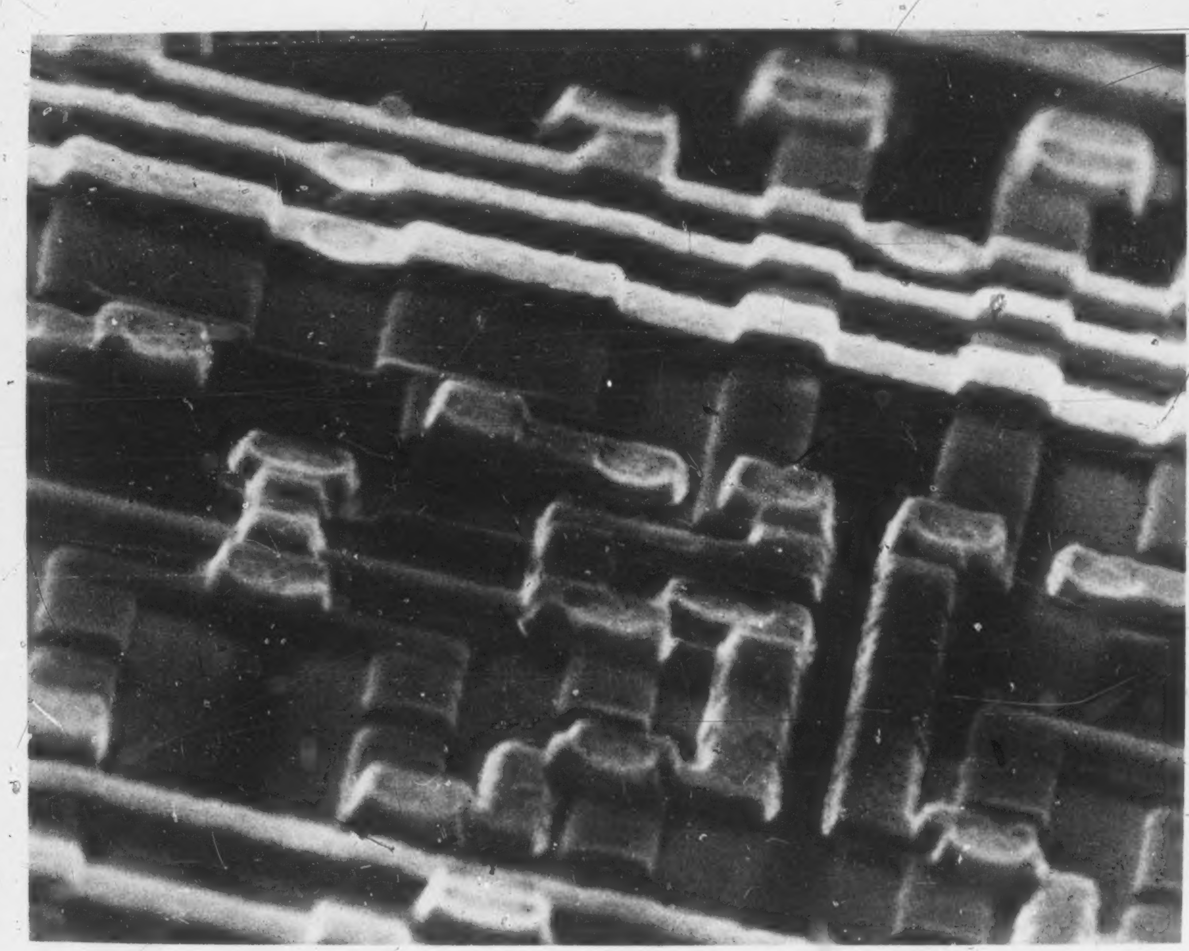
*Definitions of literacy vary among experts. For purposes of this report, a simple definition will be used. Literacy means the ability of an individual to engage in the normal modes of information exchange in a society.

Economic and Societal Impacts of Information Technology

The uses of information and the institutional structures established to collect and communicate it have long historical traditions. For thousands of years, recordkeeping systems have been a basic tool for government, commerce, and finance. They have allowed the formation and management of large organizations. Libraries and museums have existed as archival and reference resources from earliest times—perhaps even earlier than the fourth century B.C., when Alexander the Great built his library. Education also has always served basic societal functions. While the definitions of education and the institutional structures selected to provide it have differed over time and for each particular society, education has always entailed transmitting the values, cultural background, and basic communication techniques (literacy) necessary to function as a member of society.

Technologies such as writing, mathematics, paper, the printing press, and the camera were developed to improve the handling of information. Over the last 100 years there has been a rush of new information technologies that has included the telegraph and telephone, broadcast communication, photocopiers and facsimile transmission, the computer and its related software—considered, in itself, to be an important technology. These inventions have directly affected the collection and use of information. For example:

- The *speed* with which information can be communicated has been increased. Communications that less than a century ago took days, weeks, and even months, now occur within fractions of seconds.
- The *quantity* of information that can be collected, stored, manipulated, and transmitted has been increased. Data storage systems can hold trillions of characters of information that are instantly accessible through a computer. (One trillion characters of storage contains information equivalent to over 1 million books.)
- Information can be more widely *distributed* and has become more *accessible.* Data communication systems provide instant access to information and to the technology to analyze and use it.



Scanning electron micrograph of a portion of a programmable logic array with locations for up to 4,000 logic elements. The array was fabricated with the one-micrometer FET technology. Reducing the minimum device dimensions to one micrometer resulted in an increase in speed of a factor of 3 or 4, and a reduction in power dissipation by a factor of 10, as compared with previous FET circuits .

- The ability to *use* information to account for past actions and to predict future events has been improved. The invention of writing made possible the keeping of historical records. Computers analyze complex statistical models to support management decisionmaking.

These improvements in the quantitative and qualitative aspects of information handling will profoundly affect individuals and organizations that communicate and use information in some of the following ways:

- *The need for mass literacy:* The availability of printed material to the general public has not only made mass literacy possible; in the long run, it has also made it necessary. It has created a world in which it is necessary to be literate in order to fully participate in economic, political, and social activities. In fact, mass literacy has become a basic necessity for economic growth.[5] Now, with electronic media, definitions of literacy must incorporate the ability to communicate and use information technology.

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[5] T. W. Schultz, *Investment in Human Capital* (New York: The Free Press, 1971).

- *An altered relationship between individuals and organizations:* The challenge of the Reformation to traditional church authority, the demise of the feudal system, the great intellectual spurt of the Renaissance, and the birth during the 18th century of political democracy were all due, in part, to the fact that most individuals in society could obtain access to information and could communicate their ideas. If access to information is further enhanced by new technologies, individuals and groups may seek to increase their participation in governmental and organizational processes. If access, on the other hand, is not enhanced, communications technology might provide a new means by which organizations mold social thought and cultural mores and exert their authority.[6]
- *Altered structures in organizational decisionmaking processes:* Technological changes can affect the nature of decisions, the way they are made, and who in an organization makes them. New patterns of decisionmaking can, in turn, affect relationships between organizations and between organizations and their clients and employees.[7]
- *Trends toward centralization or decentralization:* Overall, the trend in communications during this century has been toward centralization. For example, more and more large cities are now served by single newspapers, and a few large networks dominate the distribution of broadcast television programs. However, access to low-cost computers and data communications capabilities can potentially provide organizations and individuals with the ability to tailor applications to their own needs and goals.

  Thus, the recent provision via cable television of several new networks to serve the interests of more specialized audiences and the appearance of small specialized newspapers serving individual neighborhoods may be harbingers of greater diversity in services and decentralization of control.
- *Changes in the political process:* Instant domestic and worldwide communications change political behavior and serve to shape public opinion in new ways and in new time frames. Computers allow large-scale and rapid polling of public attitudes and, through sophisticated mailing systems, the formation and coordination of geographically distributed special interest groups. Because they allow for instant public reaction to political decisions, some experts anticipate that new information technologies may bring about a return to a form of political participation that, although involving much larger numbers of people, is reminiscent of the "town meeting."
- *Effects on culture:* Although the new information technologies will undoubtedly affect culture, it is unclear exactly what their effect will be. More people have access to creative products than ever before. And yet the media have, as their critics have pointed out, often served the lowest common denominator of taste. It is also unclear whether information technology will serve to increase uniformity or to promote the diversity of the culture and values of society.
- *Intellectual effects:* The technology that society uses to codify and transmit ideas may affect how people conceptualize and try to solve problems. Some experts have suggested that information technology may break a limiting mental mold forced by writing upon Western thought, and that it may provide new ways to deal with the very complex and difficult problems facing society.[8]

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[6] A. Moshowitz, *The Conquest of Will: Information Processing in Human Affairs* (Reading, Mass.: Addison Wesley, 1976).

[7] H. Lucas, *Why Information Systems Fail* (New York: Colombia Press, 1975).

[8] S. Papert, *Mindstorms* (New York: Basic Books, 1980).

Extrapolating the general historical impacts that information technology has had in the past suggests that modern technological trends may have a number of effects on education:

- The nature of *literacy* for society is changing, as it did when the printing press was invented. While the goal of mass literacy, defined as skill in reading and writing, has been met—at least in the developed world—new goals as to who should be literate and what skills literacy should include may now appear:
  1. *Who should be literate:* Universal literacy—defined as skill in reading and writing for *all* people—will have to become a societal goal. The growing complexity of society, coupled with the automation of unskilled jobs, will make it increasingly difficult for semiliterate individuals to lead useful and productive lives. International economic competition and a predicted tighter labor market in the next few decades will place a greater premium on skilled, productive labor. Illiteracy is costly to society not only because it is expensive to support the unemployable but also because society must forego the social and economic contributions that the illiterate, had they been educated, might otherwise have made.
  2. *What skills literacy includes:* The term *literacy* may come to include *media literacy*—the ability not only to receive critically information presented via radio, television, and film, but also to communicate using these media. While programing in these forms has previously been done by large organizations of experts, developments such as the video cassette, the video disk, and the public access cable will place a greater premium on the ability of individuals to use these technologies in their work, at home, for their social organizations, and for political participation. Media literacy will include *computer literacy*—the ability of individuals to use an information system to help them at home and at work. While individuals will not need to be experts in computer science, they will need to know how to use computer programs and information banks and how to evaluate critically the results they get.
- The rate at which new information is generated is accelerating. The dominant emphasis will be on lifelong learning, retraining, and updating knowledge, rather than on schooling that is terminated at an early age on completion of a standard curriculum.[9] Educational curricula will increasingly focus on *learning how to learn* rather than on learning facts.
- The organizational structure and behavior of educational institutions will change. Schools, particularly public schools, are often large bureaucracies specifically designed to collect and transfer information in an organized fashion. Some experts have questioned whether they can ever adapt organizationally to a new technological environment and to new social needs. They foresee as possible either the emergence of completely new types of educational institutions based on information technology, or the radical transformation of existing schools.[10]

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[9] Stanley M. Grabowski, *Preparing Educators of Adults* (San Francisco: Jossey-Bass, 1981); Charles A. Wedemeyer, *Learning at the Back Door* (Madison, Wis.: University of Wisconsin Press, 1981).

[10] M. Frobe, et al., *Telecommunications and Higher Education*, Occasional Paper #3 (Pittsburgh, Pa.: Institute for Higher Education of Pittsburgh, 1981).

Changing Economic Base of the Nation

The U.S. economy has undergone fundamental changes during this century. A hundred years ago, the economy was principally agrarian. Then, for several decades, manufacturing dominated. Now, the service sector predominates, measured both in terms of its contribution to the gross national product and in terms of the size of its labor force. (See table 1.) The service sector, as usually defined by economists, includes economic activity that does not result in a tangible, storable output or necessitate a large base of capital equipment. Given this latter categorization, transportation and communications are usually classified as industries rather than services. Education is classified as a service.

Productivity growth in the service sector compared with that in other sectors has been particularly low. This relative lag in productivity is more significant as the size and importance of the sector grows. Some experts suggest that because of the use of economies of scale, new management techniques, and information technology, the service industry is on the brink of a major improvement in productivity.[11] They argue that, to the extent that services are more resistant to such improvements than are other sectors of the economy, their costs will become too high. Thus, those areas of the economy, such as manufacturing, that show growth in productivity will also show wage increases reflecting, to some extent, that growth. If similar wage increases take place in a sector that has not experienced a corresponding improvement in productivity, the real labor costs will grow relative to those in other sectors.

This analysis suggests that if education does not improve its productivity at a rate consistent with the overall improvement of the economy, it will face even more severe financial problems than plague it now. In fact, if other portions of the service sector are about to undergo significant increases in productivity, as some observers expect, the pressures on education to improve its productivity may be intensified.

Table 1.—Percentage Share of the U.S. Economy by Sector

	1948	1961	1976
Employment			
Agriculture	10.8	6.9	4.2
Industry	43.2	38.6	35.1
Service	46.0	54.5	60.7
GNP			
Agriculture	9.84	4.2	3.1
Industry	46.8	45.0	41.2
Service	43.9	50.8	55.7

SOURCE: T. Stanbock, *Understanding the Service Economy* (Baltimore: Johns Hopkins University Press, 1979); V. Fuchs, *Service Industries and Economic Growth*, NBER working paper 211, Stanford.

The appearance and growth of what some economists refer to as the *information sector* has paralleled the growth of the service sector. This portion of the economy, comprised of both service and traditional industries, includes those enterprises that make the machines that handle information, run the communications networks, and use technology to provide information products and services.

An overall analysis of the input/output structure of this sector, which was made for 1966,[12] determined that the information sector accounted at that time for over 60 percent of the economy. This study defined the information sector very broadly and analyzed it at the national level. It has not been repeated for subsequent years. Analytical efforts have, instead, been directed at refining the analysis and at looking at smaller segments of the economy.

Nevertheless, the original calculations are still useful in illustrating the importance of information and information technology in the U.S. economy. They also document the growth in the number of U.S. jobs requiring the handling of information and information machinery. Because information workers are generally assumed to require literacy skills more than workers in other types of jobs, these trends suggest that the country is experiencing a rise in the level of literacy needed to find and hold jobs.[13] The definition of functional literacy may need to be altered to include the ability to use computer-based knowledge.[14]

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[11] T. Stanbock, *Understanding the Service Economy* (Baltimore: Johns Hopkins University Press, 1979).

[12] M. Porat, *The Information Economy*, Ph. D. Dissertation (Stanford Calif.: Stanford University, 1976).

[13] E. Ginzberg and G. J. Vojta, "The Service Sector of the U.S. Economy," *Scientific American*, vol. 244/3, March 1981, pp. 48-55.

[14] R. J. Seidel, R. E. Anderson, and B. Hunter (eds.), *Computer Literacy* (New York: Academic Press, 1982).

Another economic trend is the growing information marketplace. The publishing industry has existed since the invention of the printing press as a relatively small sector of the economy. Now, stimulated by social pressures and new technological possibilities, it is growing into a large and important sector of the U.S. economy.[15] (Some illustrative growth figures for sectors of the information industry are shown in table 2.)

There are several indicators of this trend. First, even in the current economy, the information industry is growing at a rate of over 20 percent per year. The computer-based data retrieval market alone is projected to grow from $1 billion in 1980 to over $6 billion in 1985. Second, very large international corporations such as Westinghouse are buying into the information business, and large traditional publishing houses such as McGraw-Hill are acquiring high-technology operations in anticipation of their competing in a very different type of information marketplace in the next decade.

The plan announced by AT&T for entry into the information business is viewed with concern not only by potential equipment manufacturers and providers of communication lines, but also by newspapers and other traditional information publishers who see AT&T's new activities as creating potential competition for their businesses. Others see the potential for new information services made available by a restructured, competitive communication industry.

Table 2.—Some Representative Growth Figures for the Information Industry

Mainframe computers	1965	1975	1985
Number installed	23,200	62,800	77,600
Value in billions of dollars	$7.65	$33.6	$89.1

Desktop computers	1975	1980	1985
Number installed	4,000	326,000	10,579,000
Value in billions of dollars	$0.05	$2.4	$36.7

Estimated 1981 gross revenues in billions of dollars	
Newspapers	$17.79
Magazines	3.43
On-line data bases	1.0
Time sharing	2.455
Broadcasting/cable/special communications	28.5
Computer software	5.5
Total	$58.675

NOTE: Figures have been compiled from best available information. Estimated probable error runs −15% to +5%.

SOURCE: LINK.

Another indicator of the increased importance of information in the economy is the changed nature of international economic competition. The attention of policymakers concerned with U.S. industrial strength is now focused on competition in innovation. Competitive strength is seen as dependent on the development of new technology, of new products and services based on that technology, and of new manufacturing techniques to make those products.

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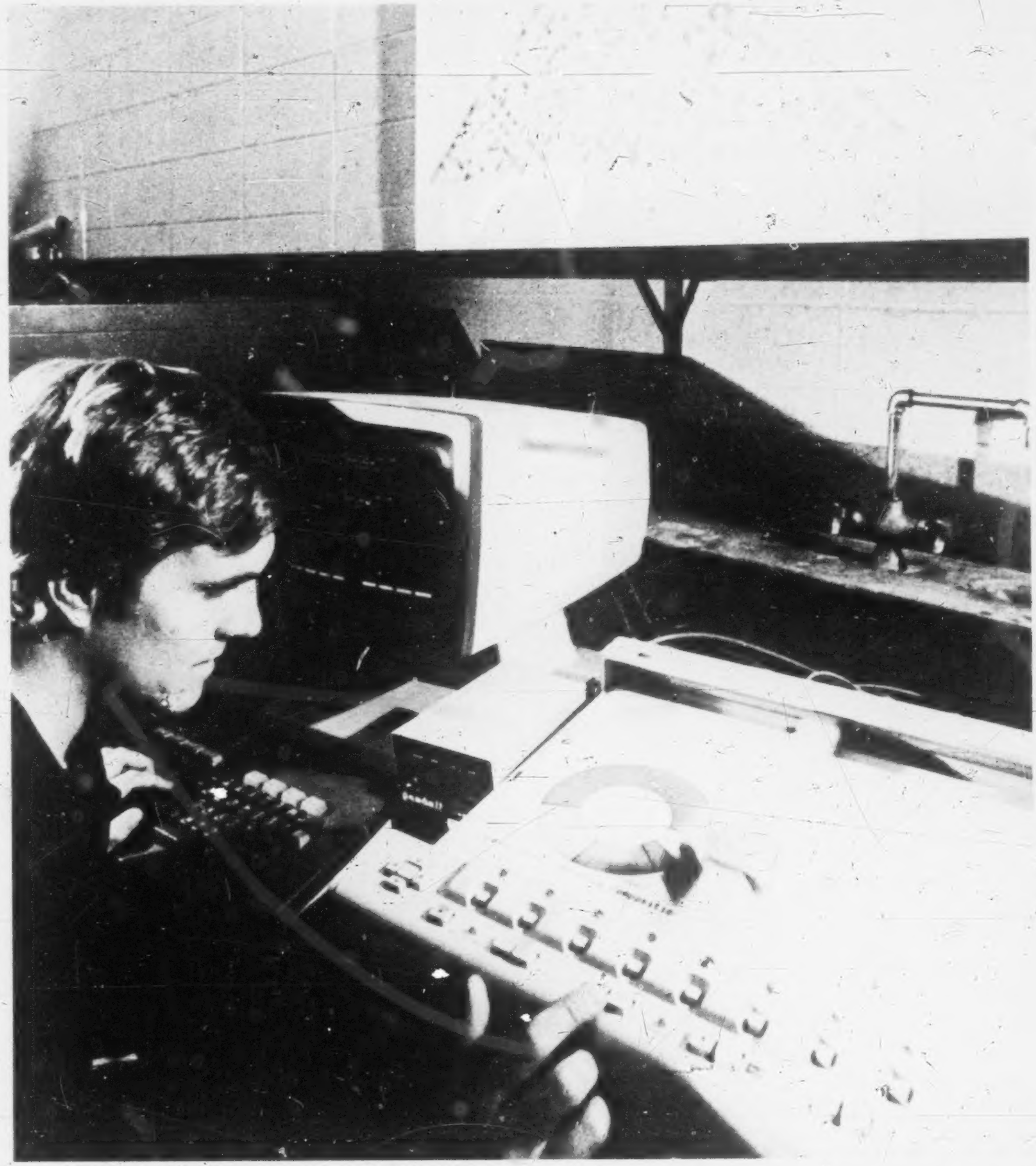
[15] H. S. Dordick, et al., *The Emerging Network Marketplace* (Los Angeles: Center for Futures Research, Graduate School of Business Administration, University of Southern California, December 1978).

Chapter 3

Implications for Economic Growth and Human Capital



This Ph. D candidate is using a console connected with Columbia University's Computing Center. A small modem connects the computer console and graphic plotter with the mainframe computer at the computer campus facility. The graphics plotter is displaying the composition of a six-element super alloy used in the space shuttle turbines and a preliminary predictive phase diagram relating to the six-element alloy's performance under stress

Chapter 3

Implications for Economic Growth and Human Capital

The principal goals underlying Federal involvement in education have historically been: 1) to contribute toward national economic well-being, 2) to assure national security, and 3) to provide an equitable distribution of economic opportunities to U.S. citizens. Because future Federal education policy will presumably continue to be predicated on one or more of these or related goals, OTA examined the links between education, technological trends, and these goals.

Findings

- Strong evidence exists for linking economic growth with the creation of new knowledge and the transfer of technology into the production of goods and services. Knowledge creates new goods and services, improved production techniques, and better management and organizational strategies.
- Many experts believe that there is a close link between the level of education and the productivity of workers—even though such a relation is complex and difficult to establish analytically.
- The link between education, training, and economic growth is becoming more critical because of structural shifts in the economy toward the service and information sectors.
- While greater access to education and training cannot directly create new jobs and may not increase overall wage levels, there are strong positive correlations between workers' educational levels and their employability.
- The rate at which automation can be introduced and the contribution it makes to the growth of productivity will partly depend on the ability to retrain workers for new jobs, either within the same industry or in a new industry. Their ability to be retrained will in turn be determined, at least in part, by their levels of literacy and their familiarity with information technology.
- There is a severe shortage of engineers, computer experts, information specialists, and other trained workers needed to support the growth both of the information industry itself and of the use of information technology in other sectors of society.
- The failure of the U.S. education system to respond to the changing needs of the information society at a rate comparable to that of foreign competitors may impose serious economic costs in the form of low growth rates and reduced competitiveness in world markets.

Knowledge and Growth

A number of studies have postulated links between information, technological innovation, and economic growth. The relationship between knowledge and economic development has been studied both in the context of the U.S. economy[1] and in that of developing countries.[2] In one analysis, nearly two-thirds of the economic growth that occurred in the United States between 1948 and 1973 was attributed to increases in the size and quality of the work force and to the development of new knowledge. Other studies have examined the direct contribution of research and development (R&D) to economic growth.[3]

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[1] E. F. Denison, *Accounting for Slower Economic Growth* (Washington, D.C.: Brookings Institution, 1979); (Kendricks article).

There are several ways in which the links between knowledge and economic growth may operate:

- Better and more timely information can lead to better organizational structures and to *improved management decisions,* which can lower costs by more efficient allocation of resources, to better scheduling of production, and to better economic planning.
- Technical innovation leads to *new or improved products and services* and in some cases to the emergence of new industries that are more competitive in the marketplace. Most of the firms in the *Fortune* 500 deal in products and services that did not exist a century ago.
- New technology can lead to *more efficient production methods* that improve manufacturing productivity. Some anticipate that the new computer-based flexible manufacturing systems will provide the critical technological underpinning for U.S. reindustrialization.

OTA has found strong support not only among economists but also in the business community for the view that the availability of literate, well-educated workers is an important determiner of productivity and economic growth.[4] The interest that business has shown in the performance of public education, and the growing investment that industry has made in specialized education and training programs are strong indicators of such concern.

High school students in Oxford, Mass., work with a learning aid that familiarizes them with electrical and electronic wiring patterns. This helps them prepare for entry-level work in the burgeoning electronics industry in Massachusetts. The school board of this old mill town in southeast Massachusetts hopes that their creation of a young labor pool skilled in electronics will help draw new industry into the town

Education and training may affect the contribution that workers make to productivity in at least three ways. First, education and training improves the *productivity of the work force* if it allows workers to use current production techniques more effectively and to adapt more readily to new techniques. Second, the growth rate of new industry is determined, in part, by the availability of individuals *trained to fill the new types of jobs* created by innovation. Finally, the process of innovation requires individuals *trained to do R&D at all levels* from basic research to product development.

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[2] T. W. Schultz, *Investment in Human Capital* (New York: Free Press, 1971).

[3] E. Mansfield, "Research and Development, Productivity, and Inflation," *Science*, vol. 209, Sept. 5, 1980, pp. 1091-1093; J. Walsh, "Is R&D the Key to the Productivity Problem?" *Science*, vol. 211, 13, Feb. 13, 1981, pp. 685-688.

[4] A. W. Clausen, "The Quality of Public Education," *Vital Speeches*, 1981.

A number of labor economists have suggested that the link between education and economic growth is becoming more important because of structural shifts toward the service and information sectors. Eli Ginzberg and George Vojta state, "Human capital, defined as the 'skill, dexterity, and knowledge' of the population, has become the critical input that determines the rate of growth of the economy and the well-being of the population. We contend that the competence of management and the skills of the work force . . . determine the ability of enterprises to obtain and utilize effectively other essential resources . . . ."[5]

The suggestion that U.S. economic growth and competitiveness are dependent, in part, on the production of new information and on the literacy of the work force has serious implications for Federal and local education policy. A decline in the performance of the educational system could be costly to U.S. society in terms of lower productivity of the work force; less flexibility for industry to adopt new production methods and management techniques; higher unemployment rates, particularly among the disadvantaged; and decreased R&D, particularly in the basic sciences and engineering.

Education and Growth

In this century, particularly since World War II, there has been a steady increase in the number of years of education completed by American workers. This trend is illustrated in table 3. The degree to which this growth in education level is accompanied by an increase in the skill levels of jobs held, however, is a matter of some debate. While some see the extension of education as evidence of the expansion of skills, others see it as a devaluation of the high school and college degree, or, in other words, as an inflation of the certification required to obtain work that is no more—and may even be less—demanding than before.[6]

Table 3.—Percentage Employment in the Business Sector by Sex and Years of Education Completed

	1948	1959	1969	1976
Male				
No school years completed	44.4	1.0	0.5	0.3
Elementary, 1-8	—	32.0	21.2	12.7
High school, 1-4	43.3	48.7	54.7	54.5
College, 1-4	—	14.7	19.0	25.7
College, 5 or more	11.5	3.6	4.7	6.9
Female				
No school years completed	32.4	0.5	0.2	0.3
Elementary, 1-8	—	22.5	14.5	8.4
High school, 1-4	56.1	63.8	68.6	65.9
College, 1-4	—	12.2	15.2	22.7
College, 5 or more	11.5	1.0	1.5	2.8

SOURCE: E. F. Denison, *Accounting for Slower Economic Growth* (Washington, D.C.: Brookings Institution, 1979).

An increase in job skill requirements could take place in three ways: 1) industrial growth and sectoral shifts in the economy could create more jobs demanding higher skill levels; 2) the availability of a more highly trained labor pool could encourage employers to raise their performance expectations, even if the basic job classifications remain the same; and 3) rapidly changing job requirements could place a premium on employees' flexibility and on their ability to be retrained in new skills.

Justifiably or not, education is, generally speaking, a major factor in the competition for jobs, and those lacking the requisite educational level are less employable. Unemployment rates by education level are shown in table 4. Two conclusions are suggested by the data:

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[5] E. Ginzberg and G. J. Vojta, "The Service Sector of the U.S. Economy," *Scientific American*, vol. 299, March 1981, pp. 48-55.

[6] Randall Collins, "The Credentials," *Society: A Historical Sociology of Education and Stratification* (New York: Academic Press, 1979).

- Education is an important selection criterion for employers.
- More sensitive to fluctuations in overall employment rates than their more skilled counterparts, less educated workers are more likely to lose their jobs when unemployment rises, and less likely to get them back when it drops.

Table 4.—Unemployment Rates by Sex and Number of Years of Education Completed

	1970	1979
Males		
High school, 1-3 years	4.8	8.3
High school, 4 years	3.4	5.5
College, 1-3 years	3.8	4.2
College, 4 years or more	1.2	1.8
Females		
High school, 1-3 years	6.8	10.4
High school, 4 years	4.6	6.0
College, 1-3 years	4.0	4.3
College, 4 years or more	2.0	3.0

SOURCE: *Chronicle of Higher Education*, citing BLS data.

Human Capital Theory

Human capital theory regards expenditure on education as an investment in improving the quality of labor input to production, hence as a factor of production. Because of the investment focus, worker income is regarded as the measure of return. Researchers have demonstrated correlations between both current and lifetime education levels and incomes. In the 1960's, human capital theory formed a rationale for much of the Federal education policy that aimed at improving educational opportunity as a means of fighting poverty.[7]

Most experts agree with the concept that, in many cases, education and training can create a more productive worker. However, many raise objections to human capital theory, both with respect to the analytical basis of the field and to the policies' implications that have been drawn from them. Chief among these objections are the following:

- The assumption that individuals make their decisions about education and career opportunities based on their reading of the labor market is questioned.
- Improvements in the quality of labor and the resulting increases in productivity are not necessarily directly reflected in a concomitant rise in salaries and wages. Hence, the societal payback from further education may be underestimated.
- Particularly at higher levels of education, individuals may decide to continue their education for another year not because it would increase their lifetime income return, but rather because they want to develop special talents and to pursue other personal goals.[8]
- According to screening theory, education does not "add value" to labor as such, but merely serves to prescreen the most able workers.[9] There is a difference of opinion between those who advocate screening theory and the proponents of human capital theory with respect to how much significance should be attributed to screening when calculating the return on investment in education.
- An increase in the social investment for improving the quality of the labor pool does not necessarily serve to increase overall levels of employment or to raise wage levels. Hence, by itself, investment in education is not an effective strategy, either to raise the income of the disadvantaged or to increase employment.[10]

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[7] *Chronicle of Higher Education,* Mar. 16, 1981, p. 2; G. S. Becker, *Human Capital* (New York: Columbia University Press, 1975).

[8] S. Rosen, "Human Capital: A Survey of Empirical Research," in *Research in Labor Economics* (Greenwich, Conn.: JAI Press, 1977), vol. 1, pp. 2-39.

[9] K. J. Arrow, "Higher Education as a Filter," *Journal of Public Economics*, vol. 2, 1973, pp. 173-216.

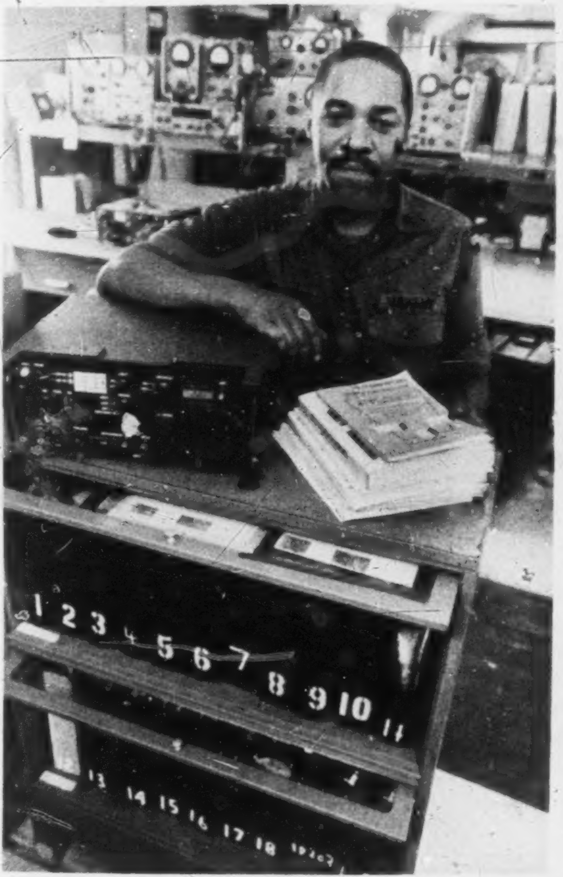
[10] *The Productivity Problem: Alternatives for Action* (Washington, D.C.: U.S. Congress, Congressional Budget Office, January 1981); L. C. Thurow, *The Zero Sum Society* (New York: Basic Books, 1980).

Need for Technical Education

The labor market is too complex to be described in simple terms of oversupply or undersupply. It can be generally said, however, that while the American work force does not appear to be undereducated in terms of the years of schooling or in terms of the number of high school and college graduates needed to meet overall employment requirements, there do seem to be deficiencies in what students have learned in school and severe shortages of graduates trained in certain job areas. And while the demand for traditional full-time, degree-oriented education may be leveling off or even slackening, the demand for specific or continuing job-related education is growing. In particular, the trend in the U.S. economy toward a growing service and information sector is creating an increased demand for education in engineering and science, especially the computer sciences, at all levels. If these needs are not met, U.S. economic growth and international competitive position may decline.

The clients for technical education can be loosely categorized into three groups, according to their respective needs:

1. The general work force—workers in all occupational categories, from blue collar to the professional, who increasingly need to gain literacy in information technology.
2. Information professionals—specialists who program, operate, repair, and in other ways directly support information products and services.
3. Information scientists and engineers—technical experts who conduct research, develop new products and applications, or teach at the college level.



There is a constant need to replace highly skilled technicians in the military service. The SP-5 who appears here in the Fort Gordon, Ga., Signal Corps Center, has been in the Army for almost 9 years, and is due for a promotion into a supervisory position. As such time, his mastery of the information contained in the field radio manuals on top of the cabinet, will be essentially lost to the Army

Information Literacy

Economists, educational experts, and business leaders assert that there is a growing need in U.S. society for at least a minimum level of literacy in science, engineering, mathematics, and, in particular, information technology.[11]

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[11] Schultz, op. cit.; R. J. Seidel, R. E. Anderson, and B. Hunter (eds.), *Computer Literacy* (New York: Academic Press, 1982);

As stated by the president of the Bank of America:

> . . . increasingly, business is looking for and the better jobs are going to, individuals with some modicum of computer literacy. Basic communication and data-processing skills are among the hottest commodities in the employment sector today.[12]

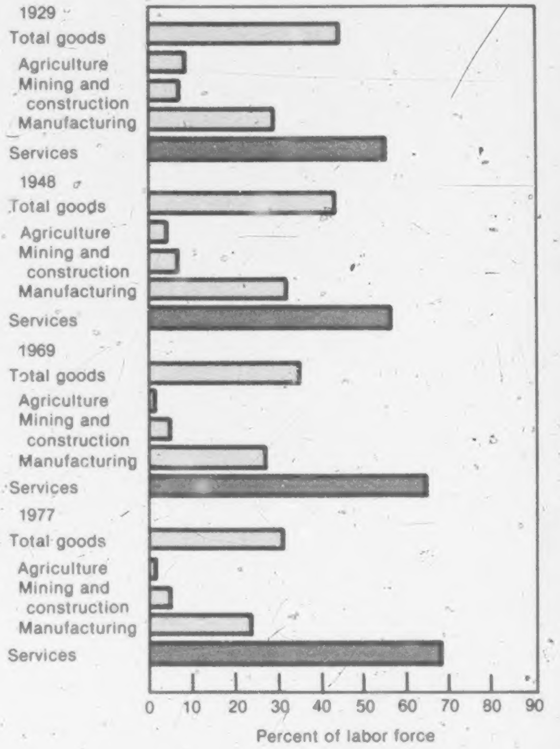
The shift in the United States from a manufacturing and agricultural economy to an information and service economy is creating more jobs with information handling requirements. The occupational mix in the service sector is compared with that in other sectors in figure 1. Furthermore, traditional jobs will increasingly require the handling of automated equipment, a trend that is already visible in the office. With the advent of automated information systems, the skills required of a clerical staff are changing. Moreover, the job skills of a secretary in the wired office of the future will be substantially different from what they are today. In fact, the concept of "secretary" may disappear altogether.

A similar trend may also occur in the factory, where robotics and other forms of computer-aided manufacturing are beginning to transform the way that goods are produced. There, automation will require that the worker learn new skills oriented toward operation and control of computerized equipment. (Some experts maintain that few of the current 20 million jobs in the manufacturing sector will remain two decades from now.)

Faced with these pressures for a more technically literate work force, the schools are apparently falling short of supplying those needs.

- **Overall achievement levels of high school and college graduates, as measured by the National Assessment of Educational Progress, are steadily falling. In particular, declines in achievement have been noted in science and mathematics.**[13]

Figure 1.—Shifts in Employment



Shifts in employment since 1929 are charted for the goods-producing industries and the service sector. The service sector includes distributive services such as communications, utilities and wholesale trade; retail trade; consumer services such as restaurants, dry cleaning and recreation; producer services such as accounting, banking and legal work, and nonprofit and government services including health, education, and national defense.

SOURCE: E. Ginzberg and G. J. Vojta, "The Service Sector of the U.S. Economy," *Scientific American*, March 1981.

Historical trends over the last decade in the achievement levels of students for selected subject areas are shown in table 5. The well-documented decline in the science literacy

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(continued from p. 29)
R. J. Marano, "Educational Disenfranchisement in a Technological Age," *Vital Speeches*, 1982, p. 222.

[12] Clausen, op. cit.

[13] National Assessment of Educational Progress, *Three National Assessments of Science*, report 08-5-00 (Denver, Colo.: Educational Commission of the States, 1978); National Assessment of Educational Progress, *Changes in Mathematical Achievement*, report 09-MA-01 (Denver, Colo.: Educational Commission of the States, 1979); *Science Education Databook*, 1980 report, SE 80-3 (Washington, D.C.: National Science Foundation, 1980).

Office design model for information gathering and communications is in use in many modern offices and has changed the design concept of many offices throughout the business community

Table 5.—Achievement Test Score Averages, 1972-79 (numbers in thousands)

	1972	1973	1974	1975	1976	1977	1978	1979
Average for all achievement tests	***526***	***527***	***533***	***531***	***538***	***533***	***531***	***529***
English composition	516	517	517	515	532	516	512	514
Mathematics Level I	541	537	545	545	546	547	541	537
American history and social studies	492	498	498	494	493	492	496	480
Biology	535	532	545	544	543	543	544	547
Chemistry	568	572	581	569	567	574	577	575
Mathematics Level II	—	—	—	660	665	666	665	657
French	539	544	560	553	553	553	552	554
Spanish	530	539	560	544	547	535	554	542
Literature	—	—	—	522	525	526	521	522
Physics	—	—	—	601	592	593	591	580
German	—	—	—	547	555	551	553	550
European history and world cultures	—	—	—	521	531	526	507	516
Latin	—	—	—	514	524	517	508	524
Average SAT scores for takers of achievement tests*								
Verbal	—	—	—	—	501	504	507	508
Mathematics	—	—	—	—	553	553	554	554

*Data not computed prior to 1976. Data for 1976 are estimated from scores of individual achievement tests for that year.

SOURCE: Science Education Databook, National Science Foundation; derived from the Admissions-Testing Program of the College Board, *National Report, College Bound Seniors, 1977*, p. 8, *1978*, pp. 13-14, *1979*, pp. 13-14.

rates of students does not necessarily imply a failure of the schools themselves. Declines in student performance might stem from social factors that are independent of the classroom. Moreover, because the schools have had to expand to accommodate an increasing number of students, some of whom have come from disadvantaged backgrounds, it may be that literacy rates have declined because more selectivity factors are operating now than in the past.

- **There has been an insufficient response by schools to the need for increased mathematical, technical, and computer literacy.**

A sociologist studying how schools in a district heavily populated by high-technology industry responded to the increased needs for technological literacy concluded that these schools have in fact moved away from a science and technology curriculum.[14] The National Science Foundation (NSF) and Department of Education, in their report to the President on science and technology education, concluded that the secondary schools were not carrying out their responsibilities effectively.[15] The report notes that the divergence is widening between the amounts of science and mathematics education made available to the few who wish to become professionals and to those who do not, a divergence further increased by a general lowering of performance standards and expectations. A shortage of mathematics and physical science teachers and the erosion of the teacher support system weaken the capacity of the schools to provide quality instruction to all students, majors and nonmajors alike.

The NSF report to the President also examined the status of technical literacy in other countries. To the extent that there is a connection between technical literacy, economic productivity and growth, and national security, the comparisons should be worrisome. Examining the state of science and engineering education in West Germany, Japan, and the Soviet Union, the report observes:

> . . . these countries are educating a substantial majority of their secondary school population to a point of considerable scientific and technological literacy, in part because they apparently believe that such literacy is important to their relative international positions.

In addition, the report states that the Soviet Union has elementary and secondary level curricula in science and mathematics that "surpass that of any other country." (A British study of engineering education noted that in Japan, even high school students majoring in the fields of humanities and liberal arts obtain enough knowledge in science and mathematics to attend engineering school and compete successfully.)[16]

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[14] Elizabeth Useem, "Education and High Technology Industry: The Case of Silicon Valley," unpublished August 1981, Institute for the Interdisciplinary Study of Education, Northeastern University, Boston, Mass.

[15] *Science and Engineering Education for the 1980's and Beyond* (Washinton, D.C.: National Science Foundation and Department of Education, October 1980).

[16] *Engineering Our Future*, report of the Committee of Inquiry into the Engineering Profession. Her Majesty's Statement Office, London, January 1980.

Information Professionals

The Bureau of Labor Statistics (BLS) has prepared a study of the growing demand for professionals trained specifically in computer skills.[17] Its estimates, shown in table 6, indicate that 685,000 new jobs will be created and 250,000 replacement openings will occur over the next decade, creating a need for nearly 1 million *new* professionals trained in computer skills.

Table 6.—Requirements for Computer Specialists (data in thousands)

Occupation	1980	Projected 1990
Systems analysts	243	400
Programers	341	500
Equipment operators	522	850
Data entry technicians	266	230
Service technicians	83	160
Total	1,455	2,140

SOURCE: *Employment Trends in Computer Occupations*, Bulletin 2101 (Washington, D.C.: Department of Labor, Bureau of Labor Statistics, October 1981).

The estimates of BLS are probably conservative, since only traditional computer job categories were examined. Other types of jobs likely to become important over the next decade include design engineers to create new types of microelectronic chips, industrial engineers trained in computer technology to support what some experts see as a necessary surge in industrial automation, information specialists to help the average user make effective use of automated data systems, marketing and management personnel for the emerging information industry, and content producers for entertainment and information services.

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[17] *Employment Trends in Computer Occupations*, Bulletin 2101 (Washington, D.C.: Department of Labor, Bureau of Labor Statistics, October 1981).

OTA was unable to find any reliable estimates of the projected growth of these types of jobs. However, these jobs will no doubt add to the total demand projected by BLS of 2,140,000 specialists by 1990. These numbers are significant because all of these jobs require individuals with similar types of knowledge and work skills. Thus, employers will be competing to fill such jobs from the same limited pool of information specialists.

Against the requirement of nearly 1 million new jobs, NSF projects that there will be a total of 157,000 baccalaureates and masters level graduates in the computer professions. Projections of community college and public and private vocational education graduates over the next decade have not been made. In the academic year 1977 to 1978, these schools produced about 67,000 graduates trained in the computer field.

Several observations can be made:

- The enhancement of productivity in the computer field will likely affect jobs at the lowest levels first. For instance, advances in programing languages may decrease the need for entry-level program coders. However, neither BLS nor NSF examined the structure of these jobs in any detail; furthermore, they did not look at trends in skill requirements.
- Some of the jobs included in the BLS estimates do not require college degrees. While no estimates have been made of the number of jobs requiring lesser skills in proportion to the total number of jobs, they are probably concentrated in the categories of data entry, equipment operation, and repair. Some low-level programing jobs may also be available.
- The production of entry-level computer science and engineering graduates will need to be sustained during a period when the number of people of traditional college age will be growing more slowly and may consist of an increasing proportion of educationally disadvantaged students.
- It is possible that, assuming no decrease in levels of support for vocational education, the community college and vocational programs may be able to meet many of these needs. It is noteworthy, however, that some concern has been expressed by business about the mismatch between current vocational programs and the needs of industry. (See ch. 6 for a discussion of vocational education and industrial training.)
- Since computers are a relatively new technology, the industry has had to live with personnel shortages from the start. One response has been to hire graduates from other fields and train them in computer science and engineering. All the major computer firms have extensive training programs, an approach that is less feasible for smaller sized companies.
- The rate at which computer science and engineering training programs can grow may be limited not only by the existing shortage of experts but also by the fact that, with salary scales that are uncompetitive in comparison with private industry, educational institutions may be unable to hire qualified faculty.
- The generally inadequate educational preparation at the secondary level could reduce the pool of potentially qualified college entrants, an eventuality which could compel colleges and universities to lower admission standards for computer science majors and to require extensive remedial programs at the undergraduate level.

The U.S. position in relationship to other countries is also unfavorable. As shown in table 7, of the four Western industrialized countries examined, the United States produces the fewest number of engineers measured as a percentage of the relevant age group. The percentages of engineers produced in each

Table 7.—Percentages of Engineering Graduates and Trends in Shares of World Trade

Country	Engineering graduates	Share of world trade 1963	1977
United States	1.6%	21%	16%
United Kingdom	1.7%	15%	9%
West Germany	2.3%	20%	21%
Japan	4.2%	8%	15%

SOURCE: National Science Foundation.

country correlates directly with the growth in their share of international trade over the last decade. While this is not proof of a cause-effect relationship, it does suggest that one may exist.

Information Scientists

Doctorate-level graduates in engineering and science are needed to support innovation and growth in a high-technology society by conducting research that builds a foundation for new development, conducting applied research and product development, and staffing college-level computer science and engineering programs. NSF found that the most serious shortages of Ph. D.'s are in computer sciences and in engineering, the two areas that are at the leading edge of technological growth. The production of Ph. D.'s in the computer sciences and in engineering has not grown significantly over the last decade. In fact, in the case of engineering, it has dropped. The situation may be even worse than the numbers indicate, since NSF estimated that in some departments nearly half the engineering graduate students are foreign nationals. While some foreigners may stay in the United States and enter the U.S. labor pool, others will return to their native countries.

Several factors have been mentioned as underlying the Ph. D. shortage:

- Engineering programs are experiencing repercussions from an oversupply of two decades ago followed by strong student antipathy in the late 1960's and 1970's.
- Computer science programs have experienced their strongest growth pressures in a time of general retrenchment in academic budgets.
- A shortage of top-level, research-oriented faculty prevents the growth of graduate programs; 10 percent of the faculty openings in computer science were unfilled in 1980.
- High private sector salaries and tight basic research funding are drawing the best faculty out of the classrooms and laboratories.
- High salaries for programers, analysts, and engineers at the baccalaureate and master levels are attracting students away from Ph. D. programs.

Chapter 4

Trends in Information Technology

Satellite communications systems depend on dish antennas to forge the necessary radio links between Earth and space

Chapter 4

Trends in Information Technology

Electronics technology in general has evolved rapidly over the last few decades, but the changes now taking place in communications, computers, and video technology are, perhaps, the most profound.

Findings

- The next decade will see a wide assortment of new information technology products and services offered to the consumer. Many existing products and services, such as the telephone or television set, will be altered and enhanced by incorporating microelectronics technology.
- These new products and services are being provided by a rapidly growing business sector called the information industry. This sector is composed of both new firms experienced in technology, and some traditional publishing and entertainment companies that are adapting to technological advances.
- While it is not possible to predict with certainty which of these products will succeed in the marketplace, it is clear that a wealth of new technology will be available to the home, school, and business. Many of these products and services will, at least initially, be directed to upper-income consumers.
- Educational users are not likely to stimulate the development of technology specifically oriented to their needs. Rather, they will use products and services designed to serve other consumer markets such as business and entertainment.
- New firms in the information industry may play key roles as new providers of educational hardware and curricula. Curricula may also be provided by a few traditional textbook publishers that are moving into new information technology markets.
- Automated work stations, such as word processors, are beginning to incorporate training and job assistance software.

Communications

Several new types of communication technologies are being developed and installed. They will offer the following improved capabilities:

- The *cost* of communications, particularly high-speed, long-distance data transmission, will continue to drop.
- Users will have a *variety* of communication services available to serve different needs.
- Communications networks will be *easier* to use, so that users can build distributed networks of interlinked computers and terminals.
- Much larger *volumes* of data can be carried over the lines.
- An *international data communications network* is evolving that will allow the establishment of high-speed communication links between virtually any two points on the globe.

Specific communications technologies contributing to this picture are two-way cable, satellite communication, digital telephone networks, new local loop distribution technologies, and new broadcast technologies, such as the direct broadcast satellite and the low-power broadcast.

Cable

Cable television transmits the signal to a television receiver directly through a wire rather than through air waves. Its principal advantages are better reception, the ability to direct specific signals to specific receivers, and the availability of more channels for use.

Originally viewed simply as an antenna shared by a community, usually in an area with reception problems or with limited local service, some cable systems have been in place for over 30 years, and their growth has been slow. Cable now, however, seems to have passed a critical threshold and is growing rapidly. This growth is spurred by the availability of a number of new services and, in the view of some, by the deregulation of the cable industry. The number of past and projected installations of cable in homes and the number of local community franchises for new cable networks to serve them are shown in table 8.

The principal technological differences between older and new cable systems are the *numbers of channels* and *two-way access.* Older cable installations provide only a small number of channels into the home, in some cases, less than 12. Some modern systems now being installed provide over 100 channels. It has been estimated that by 1990 over 50 percent of the homes served by cable will have access to more than 30 channels.[1] This additional channel capacity is important for educational purposes, since it implies the potential availability of a wider variety of programing aimed at narrower audiences (called narrowcasting). The content of television programing no longer must be determined by a limited number of channels serving a mass market.

Two-way access means that in addition to receiving programing from the cable center—the "head-end"—the user has a communication channel back to the center. In current systems such as the Qube system in Columbus, Ohio, the viewer has a hand-held keyboard through which he can make responses to program inquiries. Some two-way systems allow the connection of security devices such as fire or burglar alarms and meters that can be read remotely for utility billing.

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[1] LINK, *New Electronic Media Program.*

Table 8.—The Growth of Cable Television in the United States

	1955	1960	1965	1970	1975	1980	1985
Operating systems	400	640	1,352	2,490	3,506	4,225	6,000
Total subscription households	150,000	650,000	1,275,000	4,500,000	9,800,000	16,000,000	33,000,000

SOURCE: LINK.

Satellite Communication

In slightly over a decade, communication satellites have become a major component of the national and international communication network. The past and projected growth of communication satellite usage for a variety of services is shown in table 9. These projections of growth depend on assumptions about what new services may be developed and about how much satellite capacity may be available.

Table 9.—Projected Demand for Satellite Communications in Number of Transponders

	1985	1990	1995
Data	124	74	117
Voice	288	660	1,008
Video-conferencing	20	100	200
Video-television	100	200	225
Total	432	1,034	1,550

NOTE: Projections vary greatly.

SOURCE: U.S. Satellite Systems Inc., *Filing Before FCC,* Nov. 23, 1981.

Availability is affected by technical, economic, and regulatory factors that are independent of the existence of a potential market.

Different studies have resulted in strikingly different estimates of communication satellite usage. The numbers shown in table 9 are estimates based on these studies and are thus useful only to indicate trends.

The growth of communication satellites is closely connected with that of cable systems. Satellites stimulated the development of new types of television networks formed specifically to serve cable subscribers with specialized programing in such areas as news, sports, religion, minority interests, movies, and fine arts. This programing is distributed over a combination of satellite and land communication lines to the cable center, where it is then redistributed to the subscribers' homes.

Digital Telephone Network

The basic technology of the telephone network and its use is changing. The principal shift is from an *analog*-based system to a *digital*-based one. In analog transmission, the human voice (or any sound pattern) is transformed into electrical wave form, similar to the way music is stored on a record as a series of wavy lines. Digital transmission, on the other hand, encodes the information as a series of discrete pulses. In a manner similar to that of Morse code, different sequences of pulses represent different numbers. The sound wave is encoded as a series of numbers and then converted into sequences of electrical pulses on the line.

The shift to digital transmission will profoundly affect both the potential uses of the network for data transmission and the types of sophisticated communication services that can be provided. Digital technology allows the transmission lines to carry more information at higher rates. Moreover, transmission is more accurate. Distortion of analog signals does not usually affect normal voice conversation; however, computer data transmission is far more demanding. Digital coding allows for error correction.

The digital communications network combined with the presence of computers, both within the network and at the terminal ends, will provide a basis for a wide array of new communication services that unite the communication of information with the ability to store and process it. Most electronics technology on which the telephone network is becoming dependent is digital. Central office switching is computer-based, as are most new PBX (Private Branch Exchange) systems on the market. A new generation of telephones based on digital microcomputer electronics is also appearing.

A service already being offered is "packet-switched" data transmission, which is designed specifically to carry data between a computer and either another computer or a computer terminal. In this type of system, digital information is packaged in small pieces called packets. A packet contains information about the source and destination of the data and the relationship of that piece to the whole message. The packets are transmitted separately through the network, sometimes taking different paths, depending on which paths are free at the moment.

The telephone network was originally designed for human conversation, not for computer data transmission. That the requirements of these two types of communication are significantly different is shown in table 10. Packet switching systems incorporate computers into the network in such a way as to make it far more efficient for data transmission. It is cheaper, faster, more accurate, and eliminates some incompatibilities between the various types of equipment on the network.

Table 10.—Chief Characteristics of Voice v. Data Communication

	Voice	Data
Transmission speed	Low	Very high
Characteristics of message	Infrequent bursts of data	Nearly constant use of line
Length of time connected to network	Minutes	Hours
Sensitivity to distortion	Very low	Very high

SOURCE: Office of Technology Assessment.

Packet systems, because they lease telephone lines from AT&T and produce a different type of service for their own customers, are called "value-added carriers." They are under Federal Communication Commission (FCC) regulation. Other future services that link computers and communication lines will not be so clearly classifiable as common carriers, since computers within the network and at its nodes will provide services that look like data processing and storage. For this reason, they may not be regulated.

It has not been completely decided—either by the courts, by the regulators, or by the marketplace—which of these advanced services the telephone companies will be allowed to provide in competition with other companies in the information business, and what the rules of competition will be. The implications of the recent reorganization of AT&T, agreed on between AT&T and the U.S. Department of Justice, are still not clear, although the telecommunications and information services marketplace will be affected. Congress may wish to legislate in certain areas of telecommunications policy that it still feels to be unresolved.

Digital data communication services have been particularly important to higher education, which has been experimenting with their use to form nationwide computer networks. For example, the *Edunet* system facilitates the exchange of educational computer programs and the sharing of unused computer resources among institutions. Under sponsorship of the National Science Foundation, university computer science departments are forming a network of their departmental education and research computer systems to allow scientists all over the country to share programs, resources, and ideas, and even to work on joint research projects.

Local Distribution Networks

A local exchange is that part of the telecommunications network that provides point-to-point service within a given geographical area, ranging from a single office building to an entire metropolitan area. The telephone company has historically been the provider of this service; however, competitors, stimulated by deregulation to make use of new technology, are now developing technologies that promise to change the economics and form of local data transmission.

Thus, for example, some experts predict that as an outgrowth of the potentially large capacity of cable transmission technology, the next stage of cable services will be the provision of full two-way data transmission services within local areas. Some channels of two-way cable service will be withheld from general home use and sold to Government agencies, school systems, and businesses to form their own private cable-based communication networks. Local franchises in a few areas (e.g., the New Orleans, La., agreement with Cox Cable) are already providing for this type of facility.[3]

Other firms are experimenting with packet communication systems that use broadcast media. Networks for interoffice communication are also being developed, principally by firms interested in the office automation market which will make it possible for different types of computer equipment located in different parts of a building to communicate with one another, transferring data and processing work as needed. Finally, a new form of broadcast transmission, called cellular radio, will greatly increase the availability and use of mobile telephone communication.

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[3] *Cable TV's Third Wave: Local Broadband Communication Services, NRM,* vol. 2, 6. LINK, New York, 1981.

Both regional and office technologies promise a number of benefits to educational users: they will provide a mechanism to distribute programing among schools in a district or within a school; they will facilitate the sharing of expensive resources; and they will allow educational services to be directed outside the school—to homebound students, to students with special needs and interests, and to vocational students at their workplaces.

New Broadcast Technologies

A number of recently developed communication technologies will make new services available for the distribution of programing. While most of the industry is focusing on applications in the entertainment market, these services will also have important potential educational use.

Direct Broadcast Satellite

In a direct broadcast satellite (DBS) system, a satellite transmits a program directly to a receiver in the home or office, bypassing the intermediate step of using cable. Several companies have applied to FCC for permission to offer this service, and, if approved, it would become available toward the end of the 1980's.

The applicants have different views of the forms a DBS service might take, ranging from traditional pay television to new video technologies such as high-resolution television.* One applicant would use it as a more highly developed form of network transmission to cable and other redistributors, rather than to home consumers. It is noteworthy that at least one applicant, COMSAT, has included an educational channel in its proposal. If available, DBS could be a relatively inexpensive means of distributing educational programing, particularly in rural areas where providing adequate education and other social services is still a costly and difficult process.

A number of market, technological, and regulatory issues, some of them international in scope, must be resolved before a DBS system can become operational. Many questions remain about the potential utility and market for such types of services. Will DBS simply compete with current cable offerings, and if so, what are its advantages? Would high-resolution television find a viable market? Are special provisions needed to encourage its use for such public services as education? Finally, many users are competing for the increasingly fewer available frequencies of the electromagnetic spectrum and for orbital "parking places" for satellites.** Would current or potential uses of these resources allocated to DBS be more productive, more economical, or of greater value to society?

Low-Power Broadcast

In 1980 FCC began to consider applications for licenses to establish low-power television stations. Such stations broadcast with restricted power that limits their range to a few miles (10 to 15 miles or even less).

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*A television receiver "draws" its picture as a number of dots on the screen. Its resolution, the fineness of detail that can be displayed, is fixed by decades-old transmission standards. The higher resolution displays that occur in computer graphics systems are technically feasible. Because more information must be transmitted to produce more image detail, substantially greater bandwidth is needed for transmission.

**Broadcasting equipment such as satellites transmit their information on an assigned radio frequency. When this frequency is being used for one purpose, no other use of the same frequency can be tolerated in geographical areas where the two signals might interfere with one another.

It is estimated that low-power stations will require a relatively small capital investment to set up, possibly as little as $5,000. Furthermore, since the stations have a restricted range, many more licenses can be granted within any geographical region. FCC's stated purpose for promoting low power is to provide greater diversity of ownership and programing than that traditionally available over the restricted number of broadcast channels currently serving an area. The advantages of low entry cost and license availability may make low-power stations attractive as a medium for distributing educational programing and providing other public services.

Low-power stations can be connected and used to distribute programing from a central source similar to the way that cable operates now. Programing can be distributed by satellite or by less exotic means, such as by mailing video cassettes. A network of inexpensive low-power stations could serve as an economical way to provide television broadcast to regions with low population density. For example, the Alaskan Public Broadcasting Commission has authorized an experimental network of low-power stations to serve the residents of Bethel, Alaska. Similar systems are also being developed in Canada to serve remote northern regions.

Computers

The fundamental technological base for computer hardware has undergone revolutionary changes over the last decade that are expected to continue in the next. In 20 years, computer designers have advanced from using vacuum tubes, through solid-state transistors, to using microelectronic integrated circuits on single silicon chips the size of a dime. Researchers are now developing the ability to print electronic circuits in the sub-micron (less than 1 millionth of an inch) range.

These developments have had an enormous influence on the way computers are used and on who uses them. A mass market for computers and computer software has developed that serves retail consumers. Where computer ownership and operation used to be restricted to large, expert organizations, it now potentially extends to millions of homes, small businesses, and schools. Contributing to this trend is the fact that the cost of computing has dropped steadily and rapidly—to the point that so-called desktop computers can be purchased for no more than a few thousand dollars. These small machines have the capability of computers that two decades ago sold for hundreds of thousands of dollars, and it is anticipated that their price will continue to drop.

In addition, networks of computers now allow the owners of even a small computer to gain access to special resources—hardware, software, or data bases—and enable them to communicate among themselves. Moreover, software, which instructs the computer how to do specific types of work, is becoming available in the commercial market. In the past, computer operators were faced with the problem of developing most software themselves, an expensive task that required computer expertise. Now, there are enough users with similar computer hardware and needs to form an attractive market for software.

Other consumer devices that use microcomputer technology to increase the capabilities of traditional consumer products such as typewriters, automobile carburetors, television sets, or thermostats are also being marketed. In some cases, entirely new products, such as computer video games, are being developed. However, these are not designed to be used as computers.

These general technological trends are resulting in the availability of a number of specific products.

Desktop Computers

Desktop, or personal, computers are small machines that retail for prices ranging from less than a thousand to a few thousand dollars. They are based on microelectronic technology, using inexpensive memory and computer chips commonly available on the market. Most current desktop computers are based on one of two basic chip designs that use an 8-bit word as their fundamental unit of information.* Newer models are appearing, however, that use a more recently developed 16-bit word chip. (Larger word-size generally results in faster computation and more memory directly available to the machine.)

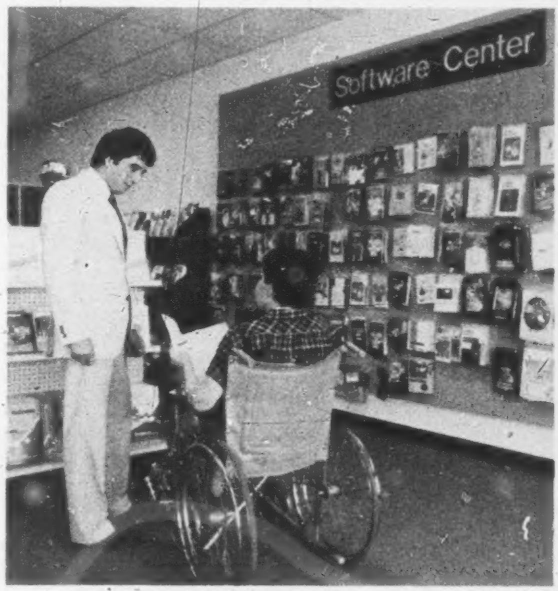
The owner of a desktop computer has a wide variety of attachments available. These "peripherals" allow the computer to perform various tasks—such as printing results, drawing graphs, communicating over the telephone line, storing information (e.g., on magnetic tapes or disks), and even generating musical sounds. While the computer manufacturers themselves offer a selection of peripheral devices, many have been designed and marketed by independent firms. The role played by these small independent firms has undoubtedly stimulated innovation in the small computer field and, by developing new applications, accelerated the growth of the market.

Over the last 5 years, the structure of the market has undergone substantial changes. Desktop computers were originally developed and sold by small entrepreneurial firms such as Apple, one of the most successful to date. However, an unexpectedly broad consumer market rapidly developed, and in response, larger, more consumer-oriented firms entered it. Tandy Corp., for example, entered the desktop computer market with a machine called the TRS 80. While not a computer company, Tandy had a national network of retail outlets—Radio Shack—through which the small computers could be sold to consumers interested in electronics. This company became a major competitor in the market.

Atari, originally a small firm manufacturing video games, but now a subsidiary of Warner Communications Co., followed soon after. Most recently, giant firms such as IBM, Xerox, and Digital Equipment Corp. (DEC) have entered the market. The growth of this market is continuing, albeit at a slower pace, stimulated by use of computers for entertainment and games, education, household management, and hobbies (e.g., computer-generated art or music).

Another market, originally unanticipated, is that of the small business user. It started slowly, principally because professional users were often nonexperts who needed more reliable assistance and better software than the manufacturers were originally willing to provide. However, growth of the business market has been rapid, and most experts expect that it will predominate in this decade.

Finally, many manufacturers see the education market as one with great potential. Apple, Atari, and Tandy have set up nonprofit



Software selection available at a Yonkers, N.Y., store organizations intended to encourage the educational use of computers. (The past and projected growth of the desktop market is summarized in tables 11 and 12, and fig. 2.)

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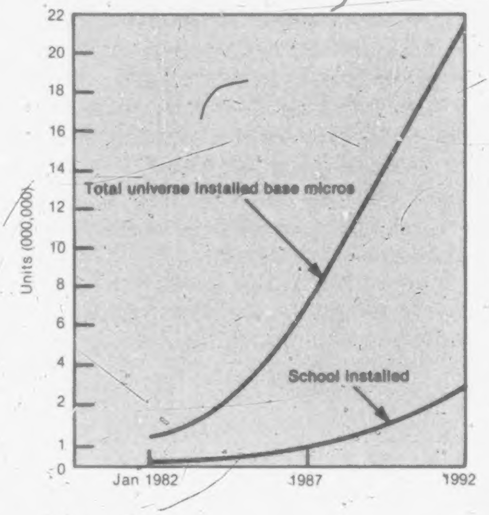
*An 8-bit word is a quantity of information roughly large enough to contain a single alphabetic or numerical character. A 16-bit word can contain twice as much information.

Growing along with the desktop computer industry are the firms that provide the programs for these devices. Nearly all of these companies are new, started by one or a few programers with a bright idea. Their packaged programs make the computer useful, and therefore attractive, to most customers. Given the current size and expected growth of the personal computer market, a single successful program can make a firm's fortune and establish it in the business. Like the independent peripheral industry, such software companies have been a major force in expanding the use of desktop computers. For example, the availability of VISICALC, a budgeting and planning program offered by Visicorp, has been cited as the principal reason that some businesses bought desktop systems. Similarly, the availability of sophisticated word-processing and accounting packages has opened the business market to small computers.

In some ways the small computer software business resembles that of traditional book publishing. A software company often purchases rights to distribute packages written by independent programers. The company, which may also assume the costs of testing and documenting the program, handles all the standard publication jobs of production and marketing. Some programers are beginning to be well known. Their names are attached to the software packages just as those of authors are to books; and, just as with books, customers often show preferences for software written by particular programers.

Figure 2.—Installed Base Micros Total Universe and School Installed



SOURCE: LINK.

Table 11.—U.S. Installed Base of Personal Computers by Market Sector[a] (units in thousands)

	1982	1983	1984	1985	1986
Home/hobby	700	1,327	2,357	3,407	4,798
Business/professional	1,236	2,345	3,975	6,025	8,428
Total	1,936	3,672	6,332	9,432	13,226

[a] Based on IDC Survey of Desktop Computers.

SOURCE: LINK.

Hand-Held Computers

The hand-held computer is somewhat larger than a normal pocket calculator, contains a microcomputer chip and sufficient memory to allow simple programs to be entered and run, and sells for only a few hundred dollars. It is both much cheaper and considerably more portable than the desktop computer.

Table 12.—Micros in Schools (installed base)

Hardware	Purchased by school district for K-12	School level			Total for 1981	Total installed
		Grades K-8	Grades 9-12	College		
Totals	10,400	16,800	22,800	30,000	80,000	145,000

SOURCE: LINK.

Its portability, however, is also the source of its limitations: the keyboard is small and difficult to use for entering large amounts of text; the display is limited to a single line of text or numbers; and no convenient, fast, bulk storage such as a floppy disk is attached. These deficiencies may be overcome by designing the hand-held computer to plug into other hardware devices, thus sacrificing its portability.

One promising application of the hand-held computer for educational use will be as an inexpensive terminal. Although containing within itself some computer power, the hand-held computer could also be used in conjunction with a communications network connected to one or more larger computers. In an educational setting, for example, students might use their personal hand-held computer by itself wherever possible. For assignments that require more capacity, the hand-held could be linked over a phone line to a larger system at the school.

Human Interface

Much research and development (R&D) in computer technology is directed at making computers and humans communicate with one another more easily, a process referred to as input/output. The input function has two basic activities: 1) instructing the computer in the task that it is to perform; and 2) reading data or instructions into the computer quickly, accurately, and inexpensively. The output function refers to producing results that are understandable and easily used either by a human or, increasingly, by some other computer or machine.

New languages are being developed to help both experts and nonexperts program computers more efficiently. Many of these languages are tailored to specific applications—such as educational use. For the professional programer, the goal is to develop languages that allow increased productivity—either faster and more accurate programing, or the creation of more complex programs. For nonexpert users, the goal is to provide a language closely related to their language and problem-solving styles.

Computer experts see a close connection between the language used to program a computer and the mental problem-solving strategy of the person using it. If the logical structure of the programing language is significantly different from the user's mental processes, the language can actually be a barrier to effective computer use. On the other hand, according to this theory, a properly designed programing language can actually guide the user to the solution of a problem. It was this latter observation that led to the creation of a programing language called LOGO, which was designed for educational use. This language teaches children new patterns of thinking about problems, patterns not only more attuned to the use of computers, but also—according to some experts—more powerful for solving very complex problems.

Data have traditionally been typed into the computer, either directly or through punched cards or some other intermediate medium. Technology is now appearing on the market to input directly, either by speaking to the computer or by showing it pictures. Present voice input capabilities are quite limited, however. Only a few hundred words can be recognized, and these only in a few specific voices for which the system must be trained. During this decade, experts expect that significant advances will be made in both vocabulary size and number of speakers that can be recognized. An interesting application of a hand-held computer would be as a personalized voice input device that is tuned to respond only to the owner's voice.

The principal developments in output technology have been in the areas of low-cost printers, graphics, and voice. Printers have historically been an increasingly expensive technology to add to small computers. Predominantly mechanical, they have not shared in the price reductions experienced by electronic devices. Recently, however, stimulated by the growing small-computer market, a number of firms have developed inexpensive printers that use electronics more extensively. These "dot-matrix" printers, selling for a few hundred dollars, print characters as patterns of small points. Besides cost, other advantages of the dot-matrix printers are that they can produce a wide variety of type fonts without changing the print mechanism and that they can be used to print graphic material.

Lately, the most active computer peripheral market in new product development has been color graphics output. Systems can now display solid shapes, in full color, with shading to reflect light sources and surface textures. While this technology is still very expensive, prices are dropping rapidly, and new and more sophisticated capabilities are coming on the market. Limited, but inexpensive and useful, color graphic capability is already available on most desktop computers. While elaborate, full-scale graphics would be useful for engineering design education and for simulators—say, for flight training—the limited capability available on small systems has not yet been fully exploited for many educational uses.

Voice output technology, while still primitive, is also improving steadily in price and performance, although it is unlikely that accurate reproduction of human speech will be achieved in this decade. Texas Instruments, with its successful "Speak and Spell" line of products, has illustrated how useful even a limited capability can be for educational applications.*

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*Speak and Spell is a small hand-held device with a keyboard and display. It speaks a word to the learner, who types in that word on the keyboard. If the word is spelled correctly, the device moves on to the next word. If not, after giving the child another chance, it displays the correct answer.

Storage Technology

Technology for storing data is steadily improving, for both large and small computer systems. The most significant developments for educational use are those storage technologies used by software publishers for the data and programs they sell. The storage medium must be cheap, durable, easily handled, hard to copy (in the view of some firms), and, most important, usable by purchasers on their systems.

Many desktop systems are designed to operate programs stored permanently on silicon chips in a high-speed memory that cannot be changed. This so-called "read-only memory" (ROM), is plugged into a socket on the computer. Its most common form is the game cartridge for the Atari and other electronic game packages.

The other major memory technology for small computers is the floppy disk, which was probably as important to the development of the desktop computer as was the microprocessor, itself. The floppy disk, which comes in 5¼- and 8-inch sizes, is most typified in word-processing systems in its 8-inch form. It provides a low-cost, rapid, and reliable storage medium for the small computer. Programs are now commonly distributed on floppy disks. There is currently a debate about whether software firms will favor floppy disks or ROMs as the medium of choice for distributing their products. Disks are cheaper to reproduce, while ROMs are now harder to copy and "pirate."

Now, economical bulk storage systems that use hard disk technology are becoming available for small computers. These systems have many times the capacity of floppy disks and are much faster and more reliable. However, they are also more expensive and do not provide a facility for data backup.

Video Technology

Like the computer and communications industries, the consumer entertainment sector, principally television, is also making technological advances. This decade is likely to see significant developments in several areas of video technology: video cassette recorders, improved quality (high-resolution, flat screen, large screen, high-fidelity sound), filmless cameras, and video disks.

Video Cassette Recorders

Video cassette recorders have already become important consumer goods. Based on consumer surveys, their principal home uses seem divided between viewing movies, particularly those not readily available at local movie houses or on network television, and so-called "time-shifting." Time-shifting means recording a program at the time it is broadcast for later replay. (According to a recent court ruling, such practice may be in violation of the copyright law, although the court also acknowledged the difficulty of its enforcement.)[3]

Video cassette recorders have become an established consumer technology despite their lack of standard recording format and their restricted marketability (to the relatively small upper-income bracket). It has not been difficult to produce and sell tapes in different formats, and time-shifting use does not depend on common standard formats.

Improved Quality

R&D is under way to develop basic new video technologies that promise better performance. Although none of these has yet reached the market place, experts think that at least a limited number will be available in this decade.

The flat and large screen protection systems that are currently available are expensive and awkward to use in small rooms. The goal of researchers is to develop a true flat display screen, since the market for such a technology would be large; not only for entertainment, but also for use in computer systems. Since manufacturers are keeping their progress in this area quiet, it is hard to predict the likelihood of success.

High-resolution television, another area of intensive development, may be closer to technological realization. However, its widespread adoption will be hampered by the need to use different broadcast formats on transmission channels with much higher capacity, as well as by the viewer's need to purchase expensive new receivers. For this reason, CBS is proposing the use of direct broadcast satellites for transmitting high-resolution programing. Cable is another possible transmission medium. Initial users are likely to be institutional users, such as theaters, that can afford to purchase receivers and pay relatively high transmission costs.

Filmless Camera

The Japanese firm, Sony, recently announced the development of a camera that operates electronically. The camera, which combines video and computer technology, "writes" a picture on a very small, reusable floppy disk. The picture is then viewed on a television display. The initial version is expensive, and its performance is limited by the resolution capability of current television displays, which is much lower than that of film. However, the future availability of high-resolution television displays will allow a picture quality as good or better than that of film.

Video Disk

A technology eliciting much interest from the education community is the video disk, a medium that stores television programing on a disk resembling a phonograph record. Educators and information publishers are excited about its potential because such disks are durable, and copies are cheap to produce. Each disk has two sound tracks, which may be played singly or together, and individual frames on the disk can be addressed and viewed. Moreover, the storage capacity of a disk is high—56,000 frames on a side. Computer data and programs can also be stored on such a disk.

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[3] *Universal City Studios* v. *Sony Corp.*, 659 F. 2d. 963 (9th Cir., 1981).

These characteristics suggest that a video disk coupled with a small computer would be a very flexible and powerful device, allowing on the same disk a combination of moving sequences, still pictures, and text, all under interactive control.

There are a number of competing technologies for recording and reading the information on a disk. However, they can be regarded as two basic types, capacitance and laser. The capacitance system, marketed by RCA, stores the information on a disk in a spiral of tiny grooves, much smaller than, but similar to, those on a phonograph record. The information is read by a needle that physically rides in the groove. RCA has marketed its capacitance system directly to the upper-income home buyer, selling it principally in competition with video cassette records as a medium for viewing movies and other packaged program materials. However, since the system does not offer recording capability, it is not useful for those who want to record from broadcasts or create their own video tapes.

The laser system stores information as transparent or reflective spots on the disk. The reader uses a laser light beam that either passes through or reflects from the disk surface. No physical contact is made with the disk surface, and the reading accuracy is immune to damage to the disk surface. Currently available laser disk systems record on one side. However, at least one firm will soon offer a technology that stores information on both sides and that can read both without having to flip the disk.

The principal benefits of the laser system are its ability to lock onto a single addressed frame and to move at random, under computer control, through the information stored on the disk, as well as the durability of the disk itself. Its chief drawback to date is cost.

The principal market for laser video disk systems has been industrial and military users. Experts differ on whether this technology will become common in the home and school. For this to happen, the cost of a computer-controlled video disk reader must drop substantially from its current price, which runs well over $1,000.

Information Services

The new information technology described in this chapter will form the basis for a wide variety of information products and services for the home, office, school, and other locations. The most significant ones will incorporate the integration of several technologies.

The three areas of information technology—computers, communications, and video—have grown up separately, connected only by their joint dependency on microelectronics. Now, it is becoming increasingly difficult to tell them apart.* This technological merger is taking place in two ways:

- The technologies are becoming integrated into each other. The digital telephone network uses computer technology; distributed computer systems use telecommunication services; video disks are controlled by microcomputers.

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*This overlap creates regulatory problems, since the communications industry is regulated and the computer industry is not. The FCC recently concluded an inquiry, "Computer II," motivated by this growing overlap, which was intended to better distinguish computer services from communications (5-FCCINQ).

- New types of information services that make use of all three technologies are being planned and offered. For example, Pergamon Press offers a patent search system that integrates a personal computer, a video disk, and a remote data base accessed by telephone to allow attorneys to search U.S. patents.

Several sectors of the industry are also beginning to overlap:

- High technology—communications and computers.
- Traditional print publishers—newspapers, magazine, and book publishers.
- The entertainment media—film, television, and radio.
- Other information-dependent firms—banks and credit card companies.

To some extent, mergers of previously independent business sectors reflect normal business growth through diversification, but the firms also see their various business activities as becoming more closely related. Thus, diversification within the information industry has become a way for companies to protect themselves against technological obsolescence. The industry overlap is motivated by two trends:

- Computer and communication technology is becoming central to the provision of many traditional information services. For example, some providers of two-way cable services plan to offer an electronic newspaper. Furthermore, traditional publishing is becoming increasingly dependent on the use of electronic systems.
- Unique new services are appearing that can be interpreted as a blend of more traditional businesses. For example, AT&T has been considering offering an in-home information service that, while resembling an electronic version of the yellow pages, competes in the eyes of some newspaper publishers with classified advertising.

While some of these new information services are described below, the list is not complete. It is possible to predict with some certainty what technological capabilities will exist over the next decade or two. It is not possible, however, to predict how entrepreneurs will use those capabilities to bring innovative services to the marketplace. The new information technology base that is being developed and installed offers a rich opportunity for such invention.

Videotex and Teletext

Some European nations, along with Japan and Canada, have been developing a technology that uses the existing television broadcast medium to bring an information service into homes and offices.

A picture on a television screen is composed of several thousand lines. During the transmission of the television signal that paints the picture line-by-line on the receiver screen, there are a number of times when no useful information is being transmitted. These so-called "blanking intervals" are needed to allow the receiver and transmitter electronics to catch up and get ready to display the next line. While some of these intervals are used to synchronize and control the picture display, many of them are unused. Information can be transmitted in these intervals. A properly modified television receiver can pick out the information and, on command from the viewer, display it on the screen, either alone or on top of the existing picture.

In a teletext system, several hundred or even thousands of pages of information are continually being transmitted. (It may take several seconds to transmit the entire volume of data.) The user selects a page for viewing; the television set then waits for that page to come along in the information stream, picks it out, stores it, and displays it on the screen.

Videotex is a more sophisticated version of this service. It requires two-way communication between the viewer and the transmitter.

The viewer requests a specific item from the central system; that page of information is then transmitted on the television signal to the viewer's screen.

The term videotex is sometimes used more broadly to include all on-line service designed to display information on demand. Such systems may use cable, telephone lines, or new packet broadcast technology to distribute their products. The advantage of videotex is that a larger data base can be made available to the user, since the entire data base does not need to be transmitted continually. It also allows for interaction between the user and the central data base. One could, for example, examine a catalog of merchandise or an airline schedule and then complete the transaction by buying a product or making a reservation. Because it allows individualized interaction with a data base, the videotex system may offer valuable opportunities for educating and training.

Broadcasters and information publishers in the United States have been experimenting in a small way with various forms of videotex and teletext services, in most cases using technology developed in Europe and Canada. A recent proposed rulemaking by FCC opens the way for their widespread introduction. The principal problems in the commercial development of this type of service will be identifying information markets, assembling an adequate and marketable data base, and pricing recorders for home television sets at a level where they can be purchased for use in the average household.

Information Networks

Closely related to videotex are various services that have developed to provide owners of desktop computers and terminals with access to computer and data services over communication networks. This business is expected to grow rapidly over the next decade. Some experts project over $6 billion in annual billings by 1985.

Providers of these services distinguish their markets by the nature of the services offered and by the types of clients they serve. *General services* offer access to a wide variety of data for a broad customer market. *Specialized services* provide narrow, but usually deeper and more sophisticated, information services to customers with special needs. Some firms serve home, professional, and small business users, while others serve large industrial clients.

There are no clear dividing lines between these markets. In general, however, the large-scale specialized data bases tend to be expensive, and using them requires a great deal of computer processing, at either the provider's or customer's end of the telephone line. Systems oriented to individual customers tend to be less costly and less specialized.

For example, using ordinary telephone lines, owners of small computer systems can connect with on-line services such as The Source and Compuserve. Companies like these offer a wide variety of information to subscribers. Although originally oriented to the needs of the home consumer, these firms are beginning to expand their network offerings to the business market. Their services now include direct access to United Press International and Associated Press news wires, stock exchange transactions, weather information, transportation schedules, restaurant and film reviews, sports scores, and even computer programs that can be directly loaded into the home or office system from the company's network.

A number of newspapers are conducting experiments to provide electronic newspapers. Customers paying a special access charge will be able to get news summaries and special features such as horoscopes and weather. Two-way services such as bill paying and teleshopping will also be offered to network subscribers. Customers can view lists of products and prices and put an order into the system. After the product is delivered, the customer will be billed via credit card. Some banks are experimenting with in-home banking services.

In addition to communication with the central network data bases, customers can exchange messages with one another through the system, allowing a simple form of "electronic mail."* The network services also use this two-way communication to provide elaborate games that can be played by several customers simultaneously.

While The Source and similar firms sell access to a wide variety of services, other companies offer more specialized products. Dow Jones, for example, sells access to its stock exchange data base. A customer with an Apple or other small computer and a communications interface buys a special program for the computer from Dow Jones and subscribes to the data base. Using the home computer, recent transactions can be monitored and historical trends analyzed.

Some firms offer large sophisticated data bases designed primarily to serve institutional customers with special information needs. Examples are:

- Bibliographic and reference data bases for research, are offered by DIALOG Information Services, Inc. (a subsidiary of Lockheed) and the National Technical Information Service (NTIS) of the U.S. Government; also the New York Times Information Service, which offers indexed abstracts and full text retrieval of news articles appearing in a number of magazines and newspapers.
- Medical information are provided by the Medline service of the National Library of Medicine; also, Harper and Row's HARFAX service publishes an on-line pharmaceutical data base.
- Legal information, such as the Legis data bank of citations and the Pergamon online collection of patent information.
- Econometric information such as offered by Data Resources, Inc.
- Natural resources data such as the petroleum reserves estimates developed by the Department of Energy and offered by the I. P. Sharp Co.

Electronic Conferencing

With electronic conferencing, a meeting is conducted in which geographically dispersed participants talk with one another over telecommunication lines. There are three categories of electronic conferencing, depending on the technology used:

- *Audio conferencing,* which uses the telephone: individuals at different locations are linked together by a conference call wherein both a loudspeaker and a microphone system are used at each location.
- *Video conferencing,* which supplements the voice connection with television images of the participants or of display charts, tables, or other graphics under discussion.
- *Computer conferencing,* which transmits messages through a central computer that stores them and forwards them on request to another participant. In a computer conference, the participants do not need to be connected at the same time. In addition, since each message in the dialog is stored as computer data, it can be indexed to topic, date, sender, and so on. This facility allows a complete running, indexed transcript to be available to the conferees at all times.

All of these conferencing modes offer an alternative to traveling for meetings, thus saving energy and time. Additionally, because computer conferencing offers time-independence, it is even attractive for use within a single office for meetings between busy executives.

Extensive research has been done on the use and effectiveness of different types of teleconferencing systems.[4] Each has its own advantages, disadvantages, and costs. Video conferencing, for example, will be more expensive than computer or audio conferencing; however, computer conferencing offers time-independence.

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*For example, Congressman James Coyne uses The Source as a way to stay in electronic communication with his constituents.

[4] J. V. Johansen and K. Spengler, *Electronic Meetings* (Reading, Mass.: Addison Wesley, 1979).

Experimental computer conferencing systems have been operated for some time by Turoff at the New Jersey Institute of Technology (the EIS system) and by the Institute for the Future (the PLANET system). Commercial systems are now appearing on the market. Infomedia, a small California-based firm, is marketing its NOTEPAD conferencing system to large industrial and government clients.

Advanced Business Services

AT&T is planning to offer an advanced data communications service known as ACS (Advanced Computer Service). This service, principally designed to serve major corporate users, will integrate high-speed data communications for computer applications with such uses as teleconferencing (video and audio) and facsimile transmission. Satellite Business Systems is planning to offer a similar service, and other firms may also enter the market soon.

One principal advantage of these new computer-based communication systems is that they will allow the integration of communication services economically over a single high-capacity channel. Incorporation of computers within the network will provide the customer with more flexibility, since the network can handle incompatibilities between different types of computers and terminals and can also manage the flow of work among several interconnected computers. The network can even offer a customer data storage and retrieval, as well as computer-processing services.

Data networking has been of interest to higher education for several years. Post-secondary education institutions may find fewer technological barriers and lower data communications costs if they link their computers and use teleconferencing for teaching and management. Industrial firms that install ACS-type services almost certainly will use them to provide education and training for their employees.

Chapter 5

Educational Uses of Information Technology

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HELLO, CLASS.  I AM YOUR TEACHER, MS.
GRUBER AND I AM PRESENTING SOME OF
THE INFORMATION YOU WILL BE USING ON
THE COMPUTER THIS YEAR.

FIRST LET ME PRESENT THE SIMPLEST
COMMANDS THAT YOU WILL NEED TO HAVE
THE COMPUTER UNDERSTAND YOU. YOU, AND
LATER YOU AND A PARTNER, WILL BE USING
THESE COMMANDS TO WRITE PROGRAMS THAT
WILL BE SAVED ON TAPES AND SHARED WITH
YOUR CLASSMATES.  THIS PROGRAM IS
CALLED"PROBLEM SOLVING WITH COMPUTERS"
AND IS DESIGNED TO HELP YOU LEARN
HOW TO ATTACK PROBLEMS AND OVERCOME
DIFFICULTIES.

EVERY PROGRAM LINE MUST HAVE A NUMBER AT
THE BEGINNING.FOLLOWING THE NUMBER IS A
COMMAND.  THE FIRST COMMAND YOU WILL
LEARN IS PRINT, WHICH CAN ALSO BE
REPRESENTED BY THE SYMBOL ?.  ALL
PRINT STATEMENTS MUST BE IN QUO
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An elementary school teacher in Lexington, Mass., prepares a program for presentation to her students

Chapter 5

Educational Uses of Information Technology

Since the development of the radio, people have proposed that communications technology provide major improvements in the delivery of education. Research on "teaching machines" dates back to the 1940's, before the general introduction of computers into the marketplace. Since that time, there has been continual research, development, and implementation of techniques for using information technology in various aspects of education.

OTA investigated what is known and what has been proposed about possible applications of information technology to education.

Findings

- Information technology is capable of becoming a major resource for the delivery of educational services over the next decade:
  - It can be an effective delivery mechanism for most existing forms of education.
  - It provides capabilities for responding to new demands that traditional schoolroom education cannot meet adequately.
  - The cost of information products and services for educational applications will continue to drop with respect to other items in the educational budget.
- The principal benefits will be realized from combinations of new technologies rather than from any single device.
- Most educational applications will be based on hardware technology that is originally developed for a broader consumer market. The only exceptions will be devices designed for specialized industrial uses—e.g., flight training for airline pilots—or education and training for the handicapped.
- It is impossible to predict with certainty the technological base that will exist for educational use. Some of the products and services now projected for the next decade, and described in chapter 4, may not survive the competition for the consumer's money. This uncertainty may inhibit the rapid development of software and services particularly oriented to the education market.
- The provision of high-quality, reasonably priced educational software is the principal technological challenge. Low-cost hardware will be widely available to most homes, offices, and schools.

Functions of Educational Technology

There are a variety of ways in which computers and communications technology can provide educational services. In some cases, different types of applications will require different technologies; in other cases, the same type of technology can be used to provide different types of services.

Passive Instruction

The oldest instructional use of information technology is simply to present information. The textbook is the traditional passive instructional system. Projection media—slides, filmstrips, overhead transparencies, and pictures

—are more modern forms. Educational radio and television have experienced quiet but steady growth since the late 1950's and early 1960's.[1] Video cassettes and video disks will provide even more flexible tools for presenting video-based instructional material.

The best known recent examples of passive instructional programing are the "Sesame Street" and "Electric Company" programs produced by The Children's Television Workshop with partial Federal support. These programs were intended to supplement, not replace, normal schooling. Sesame Street is intended to teach preschool children some basic concepts and learning attitudes. Electric Company is principally aimed at supplementing reading instruction at the grammar school level.

At the other extreme, a full alternative to traditional education is the "Open University" in Britain, which has conducted a full college degree program for over 11 years, based principally on passive instruction using the broadcast networks. In the United States, the Corporation for Public Broadcasting is developing an educational program along similar lines in cooperation with universities across the country.

New technology for video production is also having an impact on educational uses. *Computer animation* systems have become considerably less expensive than older, hand animation techniques. *Video processing* uses computers to perform elaborate modification of video images. Both of these technologies are widely used in commercial television and motion pictures, but they are also particularly attractive for instructional application in which concepts and processes that are subtle and difficult to visualize need to be illustrated. Complex physical processes, such as fluid flow or load stresses on structures such as bridges, can be simulated on a computer and displayed as dynamic graphic images. In addition, video cassette recorders (VCRs) and video disks promise to relieve students from the dictates of schedule. The VCR, in particular, allows—copyright law permitting—instructors and students to copy instructional programs off the air and play them back at some later time. Video cassettes and video disks will provide alternate modes of broadcasting for the distribution of instructional material.

Passive instruction systems have the following characteristics:

- All educational decisions are in the hands of the providers; what information is to be presented, for how long, in what sequence, and even—in the case of such current instructional broadcasting—the schedule—when it is shown.
- The boundaries between entertainment, public information, and educational services can become blurred. A Shakespeare play, a concert, or an informational series such as the successful Cosmos series carried by the the Public Broadcasting System, may all be considered important instructional resources as well as entertainment.

Interactive Instruction

This technology is used to teach a specific subject or skill directly to a student, guiding the learner through a sequence of steps involving the presentation of information, drills, and exercises designed by an instructor. Interactive instructional systems require the student to communicate with the device, allowing the system to vary the pace of instruction, select among alternate sequences of presentation, test for understanding, and alter the content according to the specific needs of the individual.

Computer-assisted instruction is the best known interactive technology. A student sitting at a computer terminal works through a series of "frames" that teach and test understanding.* If the student is progressing slowly, the computer branches to an alternate style

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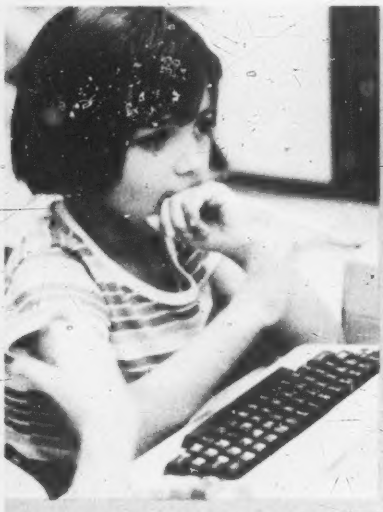
[1] P. J. Dier and R. J. Pedone, *Uses of Television for Instruction, 1976-1977*, NCES/CPB, 1979.

*A "frame" is a display on the television screen in a SAI system. The term dates back to programed learning research in which a frame was a unit of material presented at one time.



Capitol Children's Museum, Washington, D.C.—Consternation is a constant in the first phases of instruction . . .

. . . but the student's discovery of wrong responses . . .

. . . is followed by the sense of reward for right responses which makes the anxiety of exploring the unknown bearable

of presentation or a remedial section. If the student has mastered that section, the computer jumps ahead to more advanced material.

The Plato system was one of the better known experiments. It was developed by researchers at the University of Illinois and Control Data Corp. With principal funding from the Federal Government, the system originally combined a new type of interactive graphics terminal with a large multiterminal computer system and an elaborate language specifically designed to create instructional programs. While Plato was originally a very expensive experimental system, most of its underlying concepts survive in commercial instructional systems now marketed by Control Data.

Four factors have more recently revived interest in interactive instruction: 1) the rapidly declining costs of computers and the advent of the desktop computer, 2) the escalating labor-intensive costs of traditional schooling, 3) an improved understanding of how to create instructional packages, and 4) the development of alternative delivery mechanisms that link the computer with other technologies, such as video disk and interactive cable.

The video disk is a good example of how new technologies can be combined to form instructional systems. The video disk contains an extensive data base of text, still images, and film. The computer controls the sequence of presentation and, using an educational program contained on its floppy disk and information stored in the remote data base, interacts with the student.[2]

The video disk, for example, might contain several thousand images of microscope slides. The data base would have full descriptive information on the subjects illustrated by the slides, indexed in various ways. Educational software on the computer would take a student through sequences of slides and text presentation, providing information and administering tests. While the computer program would be designed to achieve a specific instructional purpose, the slide catalog and data base would be intended to be more widely applicable for research and education.

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[2] L. F. Eastwood, "Motivation and Deterrants to Educational Use of 'Intelligent Videodisc' Systems," *J. Ed. Tech. Systems*, vol. 7(4), 1978-79, pp. 303-335.

Several experiments are under way to develop instructional packages using combinations of video disks and personal computers. The Minnesota Educational Computing Consortium is developing a series of video disks in basic economics. The first disk of a planned 6-disk series has been produced and tried in the classroom with favorable results. Other companies are developing products aimed at the industrial training market; and a few firms, such as IBM, are already using interactive video disks for employee training.

Interactive instructional technology has the following characteristics:

- It allows the system to customize teaching to the particular level of understanding, learning style, and ability of each individual student.
- The system can be designed so that students can pace themselves.
- Because individualization and self-pacing may not fit well with traditional schooling, large-scale implementation of interactive instructional technology in the schools may engender substantial institutional resistance.
- Instructional software is often divided into discrete packages, each designed to teach a specific skill or item of information. An instructional curriculum (say, a fifth grade mathematics course) is a collection of these packages, which, for a full course, may number into the hundreds.
- Extensive design effort is needed to create each module. The material to be taught must be broken down into frame-sized pieces. Tests of understanding must be devised, and the paths that students are most likely to take in going through the material must be anticipated.
- Because they are so carefully tailored, interactive curricular packages are inflexible. They are not generally useful for any purpose, clientele, or environment other than the specific one for which they were designed.
- The skills required both to produce software and to assist students with its use are substantially different from traditional teaching skills.
- Some experts suggest that smaller instructional modules can be designed to fit into the regular course of instruction, permitting a gradual introduction of educational technology. Others maintain that the principal educational benefits of technology are lost with such an incremental approach.

Learning Environments

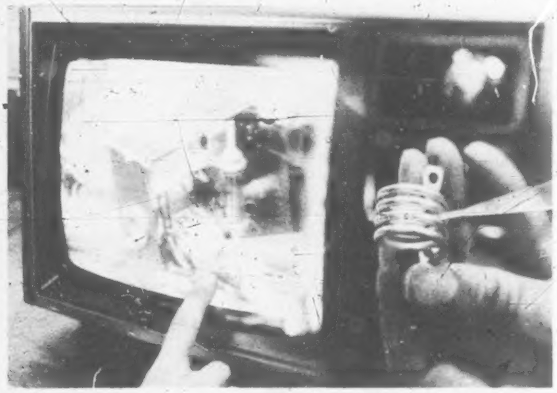
The interactive instruction technology described above can be used to create a special environment—a language, simulation, or data base—that can be manipulated by the student.

For example, special computer languages, such as LOGO, can help learners gain particular problem-solving skills. Languages such as VISICALC, a system designed for business users of small computers, can be a powerful tool in teaching accounting principles and financial planning techniques.

Another form of learning environment is the simulation. A simulation of a laboratory experiment for a physics course, for instance, might present on a television screen a variety of weights and springs. The student would be allowed to "connect" them in various configurations, to apply forces of prescribed amounts at different points in the arrangement, and to measure and record the results. Working with this system for only a few days, a student would learn some basic principles of mechanics. As another example, large-scale simulations can be made of physical processes or of equipment that might be too expensive or dangerous to use in person. Simulated nuclear powerplants provide vehicles for training new operators; simulated aircraft are used for pilot training.

For medical education, computer-controlled robots can be used to simulate injured or ill human beings. A small computer presents the student with an instructional sequence where proper techniques are illustrated using a computer-controlled video disk. The student then

At Fort Gordon, Ga., Signal Corps Center, video simulation is used to teach repair techniques. If instructors were to use actual equipment, it would have to be returned to a repair shop for costly work and expensive 'downtime'



The actual coil shown on right, whose removal and respacing would require costly downtime for the instructional radio set. The student is given the learning experience by TV instead, testing his notion of the proper technique against solutions stored on the random-accessed video disk

practices on a dummy equipped with sensors monitored by the computer, which, in turn, presents the results to the student.

Simulations of economic and social systems are used to teach political science, economics, and management. Business management games are one of the earliest educational applications of computers, and they have been deeply integrated into the curricula of many business schools. Other educational applications range from simple economic simulations on small computers to elaborate simulations of city management and international politics that require very large computer systems. The Defense Department makes extensive use of computer-based simulations to train senior decisionmakers in crisis management.

Using information technology to provide a learning environment has several implications:

- An instructional program can be applicable over longer course periods and for a greater variety of educational uses than can an interactive module that concentrates on a single teaching unit.
- Since the interaction is so flexible and is directed in large part by the students, instructors and students need documentation and supplemental curriculum materials appropriate for using the system to meet their particular educational objectives. Except for large simulations (such as flight trainers) that may require special hardware, the principal cost of "learning environment" applications will be in developing these supplemental curricular materials. Developmental costs for the programs will, in general, be written off against a much larger customer base.
- Because it fundamentally changes both content and the way material is presented, use of an automated learning environment may require extensive changes in course content or even a broader redesign of an entire curriculum.

Information Resource

General information literacy is needed for all individuals to work and to participate fully in an information society. In addition, for most professions, specialized computer and communication-based systems are rapidly becoming indispensable tools of the trade. Students must learn how to use these services as part of their early training.

For these reasons, in addition to being an instructional tool, the computer in education is viewed as an intellectual and problem-solving resource, akin to the library or laboratory. Information services will need to be both broad enough to support general education and specialized enough for particular subject matter. Examples of specialized systems include computer-aided design systems for industrial engineering students, on-line legal or medical information retrieval systems for use by law students or doctors, and automated accounting and financial analysis systems for business students.

In addition to these specialized resources, students in all fields will need constant access to information services and computer facilities for their work. One engineering school is experimenting with providing a desktop computer to some of its entering freshmen, with a view toward giving computers to all students in the future. A graduate school of business has already adopted a similar policy for its entering students. The leader of the movement to provide all undergraduate students with computer access has been Dartmouth College, which, for well over a decade, has operated with a policy of universal computer literacy and free student access to computer terminals.

The role of the computer as an educational resource on campus is blending with the view of libraries as automated information centers. Many college and university libraries have been among the leaders in this movement—first in automating their management, then in providing users access to computerized bibliographic services. Their ultimate goal is to provide full-text, on-line retrieval. As these trends continue, the computer center and the library will actually merge into a single, automated information utility.

Software Library of the Columbia University Computer Center. Software is placed into the computers on an hourly basis to the department utilizing the computer

Regional and national networks will provide scholars with access to information and computational resources anywhere in the country. EDUCOM, a nationwide consortium of universities and colleges, has been developing this concept for several years and now offers its members access to EDUNET, a nationwide resource-sharing data communication network.

Administration and Instructional Management

Information technology can be used by the teacher to help plan coursework and manage the classroom. Computers not only assist with mundane daily tasks such as grading and recordkeeping but can also help keep closer track of the daily accomplishments and problems of individual students. Teacher attention can, thus, be more focused on individual student needs. Teleconferencing via radio, television, or computer allows teachers to exchange experiences, develop curricula, and coordinate educational programs among a number of schools in a district.

Distribute Education

The distribution of services to those who need them has always been a difficult problem for the educational system. For as long as education has been provided by schools, the distribution problem has been responsible for institutional constraints of both time and location on the student. That schooling takes place on a physical campus, attended principally by young people, may be more reflective of the limitations of the traditional schooling system than it is of the current needs of society for education. Chapter 6, which examines the state of the educational system, concludes that

At the Oxford High School, Oxford, Mass., students operate the Digital Equipment Corp. mainframe computer that controls the student records system for the school district

a significant gap may exist between the forms of educational needs of a modern information society and the traditional institutional forms of educating.

Information technology is a tool that can address these two distributional problems—distance and time. In the past, television and radio have been used for this purpose, often to good effect. However, their applicability has been limited both by the need to use expensive and scarce broadcast facilities to serve a relatively small clientele and by the inability to provide interactive services.

Modern technology removes these barriers. Communication facilities such as cable, direct broadcast satellite, low-power television, and video cassette and video disk will greatly increase the number of information channels coming into the home and office. Two-way cable, remote conferencing facilities, and optical video disk microcomputer systems provide the capability for interactive education.

Among the particular applications of information technology for distribution are the following:

- *General educational services to dispersed populations:* Some geographical regions need to provide schooling to a sparse population spread over a large area. Communications technology such as direct broadcast satellite or low-power television allows educational programing to be broadcast at low cost to small rural communities and even to individual residences. Video cassettes, video disks, and personal computer programs can be distributed physically by mail.
- *Specialized educational services to small populations:* Some groups in society that have very specialized needs for educational services are not concentrated geographically. Only by providing courses regionally or nationally can a critical mass of students be assembled to justify the expense of the course. Information systems provide that wider market. For example:
  - Advanced professional training, especially continuing education in such fields as medicine, law, and engineering, in which knowledge advances at a rapid rate.
  - Unusual educational needs, such as accelerated science programs for the gifted or courses conducted in a foreign language.
  - Instruction in subjects for which experienced teachers are scarce or courses conducted by outstanding scholars and leaders in a field.
- *Education for the homebound:* For a number of reasons—e.g., illness, physical handicap, or age—many individuals in society cannot travel physically to attend a class. Information technology can provide educational services directly to the home, hospital, or workplace.
- *Job-related education and training in the workplace:* There are a number of barriers to workers who wish to take job-related instruction. Attending regular classes is difficult due to competing demands on their time, travel to a campus may be burdensome, and there is reluctance on the part of some older individuals to sit in a classroom and compete with younger students.[3] Information technology, by bring-

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[3] R. L. David, "Adult Higher Education: Thinking the Unthinkable," *Adult Continuing Higher Education Conference, Region V,* Appalachian State University, April 1977.

ing the course to the workplace, can remove some of these constraints.

Testing and Diagnosis

Computers have been used for some time to grade and analyze the results of college admission exams, intelligence tests, and a variety of psychometric examinations designed to explore the values, attitudes, and thinking patterns of individuals. Educational testing can be thought of as having four basic roles:

- *Strategic:* Testing helps assess a student's general levels of understanding and learning strategies. It is used to determine what classes and courses of study a student should pursue, and what instructional approaches would be most effective for him. After a course, testing measures the skills and knowledge that the student.
- *Tactical:* Testing also takes place during instructional sequences to determine how the student is progressing through the course and to detect and diagnose difficulties the student might be having.
- *Gatekeeping:* Testing plays an increasingly important role in supporting decisions on admissions to institutions and to programs of study. It is a basis for allocating scarce resources (e.g., admission to a prestigious college or university) and for the granting of licenses to practice professions.
- *Certification:* Testing plays an important role in certifying the knowledge and skill of individuals, qualifying them to ~~pursue~~ professions such as medicine or law, or attesting that they have progressed along certain educational or training paths.

Modern information technology will likely have several effects on testing:

- Continual testing of students' progress and levels of understanding is an important pedagogical tool, even in a nonautomated teaching environment. However it is very demanding of a teacher's time. Automated systems will allow much closer monitoring of student and class progress in a normal classroom environment.
- Automated teaching systems depend on continual testing and evaluation to direct the presentation of material.
- Automated instruction may lead to a decoupling of instruction from institutions —in the sense that a student moves freely between home, job, and school for coursework. This trend will create greater need for strategic testing to determine appropriate instructional programs for students.
- Institutional decoupling will also require more testing for purposes of certification. Traditionally, an engineering degree was obtained by following a course of study at one department. Certification was the degree earned by successfully completing the program.
- The accelerating growth of knowledge is pressuring professions such as medicine, law, and engineering to require retraining and periodic renewal of certifications.
- If traditional forms of education become increasingly expensive and, hence, scarce, gatekeeping requirements will inevitably continue to grow in importance. The current competition for entry into medical school illustrates this trend.
- On the other hand, automated learning systems may make certain types of education and training far more accessible and affordable. If that occurs, gatekeeping may take place not on entry to the education program, but in licensing to practice.

Capabilities of Educational Technology

None of the technologies and services described in the chapter 4 overview has the capabilities required to support all of the applications listed above. Hence, the growth of an extensive automated education network will depend on the integration of information technologies.

Each particular technology—cable, personal computers, etc.—has some but not all of the capabilities necessary to provide effective education. Thus, the basic message is that different information technologies will need to be linked in order to provide all of the capabilities needed for extensive automated learning systems to be developed. As shown in chapter 4, such integration is already taking place for other applications.

Cost and Effectiveness

For many years, the cost and effectiveness of educational technology has served to circumscribe the debate about whether and how it should be used. OTA found that:

> **There is a substantial amount of agreement that, for many educational applications, information technology can be an effective and economical tool for instruction.**

This conclusion is based on a number of observations:

- Research exists, some of it dating back years, to suggest that students do learn as well or better from educational technology than from conventional means. Little evidence exists to the contrary. Much of the past debate centered around whether technology was *more* effective than conventional means and hence warranted substitution for traditional classroom instruction.[4]
- Costs for labor-intensive education and training methods continue to climb faster than the inflation rate, while costs for information technology continue to drop precipitously. These trends will result in a steadily growing number of applications in which technology-based instruction is clearly the most cost-effective method.
- For many educational and training needs —e.g., educational services to the homebound, to geographically isolated regions, or to the workplace—there are few viable alternatives to the use of technology, provided that it works adequately. In a growing number of instances, teachers qualified to teach in certain fields—such as science, mathematics, or bilingual education —are difficult to find. In these cases, technology may be the only means by which such education can be provided.

This is not to say that there are no potential limitations or dangers in the uncritical use of educational technology nor that there is no need for additional research in the field. In fact, in the eyes of some critics, a number of questions remain unanswered.

- Will access to computers reduce the ability to practice and learn basic skills? Some parents and teachers are concerned that student use of hand calculators may lead to the atrophy of simple computational skills. Some modern word processors incorporate spelling correction facilities, and future systems will probably incorporate simple grammatical analysis and correction. Will use of such technology decrease a student's grasp of writing mechanisms?
- Does the medium have characteristics that, when exploited, distort the educational message or produce subtle side effects? Some observers, for example, have suggested that television educational programs such as Sesame Street may reinforce short attention spans. A similar example is the finding of some developers

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[4] See, for instance, W. L. Schraumm, *Big Media, Little Media* (Beverly Hills, Calif.: Sage Publications, 1977); A. Bork, "Interactive Learning," *Amer. Journal Physics* 47(1), January 1979, pp. 5-10; L. J. Seidel and M. L. Rubin, *Computers and Communications Implications for Education* (New York: Academic Press, 1977); J. Edwards, et al., "How Effective is CAT? A Review of the Research," *Educational Leadership*, November 1975, pp. 147-153; and R. Dubin and R. A. Hedley, *The Medium May Be Related to the Message: College Instruction by TV*, Center for the Advanced Study of Educational Administration, University of Oregon, Eugene, 1969.

of interactive computer-based reading programs that, in order to maintain student attention, shorter passages must be used on video screens than would be needed to maintain student attention for reading exercises on paper.

- Most research on technology-based education has focused on the development of well-defined skills, such as arithmetic computation or foreign-language vocabulary. While proponents argue that computers can encourage the development of new problem-solving skills,[5] critics suggest that education of the more general conceptual skills could suffer.
- If, over the long term, education is provided principally by technology, what are the unintended long-term impacts on social, cognitive, and psychological development? Very few answers to this important question are known. However, since it would take several years before technological and institutional changes could create such a possibility on a massive scale, there seems to be adequate time to study it.
- Do particular characteristics of information technology subtly favor some types of students psychologically or cognitively? Do differences exist that tend to favor performance by sex, age, social class, or values? These questions are important when dealing with issues of social equity.

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[5] S. Papert, *Mindstorms* (New York: Basic Books, 1980).

Chapter 6

The Provision of Education in the United States

Access to new information technologies can be provided in a number of, and in many nontraditional, ways. In the Oxford School District, Oxford, Mass., computer programs are provided by bus throughout the school district

Chapter 6

The Provision of Education in the United States

Within all societies there is an educational system that is both central to and dependent upon the rest of society. Its role, its functions, and the resources available to it are determined by the very social institutions for whose maintenance and effectiveness it is responsible.[1] Thus, while all societies educate, the particular form that any educational system takes will depend in large measure on the nature of the society of which it is a part.[2] How a particular educational system evolves will also depend on the nature of the decisions made about it. For within the constraints established by the socioeconomic order, there are a variety of possible educational outcomes.

Findings

- Recent social and economic developments have fostered a reevaluation of how education should be treated—as a public or as a private good.
- Because they are capable of providing specialized educational services to narrow segments of the educational market, the new information technologies will make it easier to produce and distribute education in the marketplace.
- If education is increasingly treated as a private good, and decisions about education are made in the market instead of in the governmental arena,
  - — individuals and groups that can afford to buy educational services may be more satisfied with the kind of education that they receive, but
  - — fewer social resources may be made available to support what traditionally have been regarded as the public benefits of education.

Social Change and Education in America

All societies educate; education is necessary to either maintain or to structure the social order. Education mediates between individuals and society. It is the means by which societies transmit acquired knowledge, attitudes, values, skills, sensibilities, and symbols from one generation to the next—and thus the means by which individuals learn the skills and roles necessary to function in and to act upon societies.[3]*

Individuals and societies have differed with respect to how they believed educational deci-

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[1] Lawrence A. Cremin, *Public Education*, Basic Books, 1976.

[2] Herbert A. Thelen, and Jacob W. Gretzels, "The Social Sciences: Conceptual Framework for Education," *The School Review*, vol. LXV, No. 3, autumn 1957, p. 346.

[3] Ibid; see also, Charles Weingartner, "Redefining Education in a Changing Present for an Uncertain Future," paper presented at meeting of Chief State School Officers, Orlando, Fla., winter, 1980; and Charles E. Bidwell, "The School as Formal Organization," *Handbook of Organizations*, James G. March (ed.) (Chicago: Rand McNally & Co., 1965), pp. 972-1,969.

*Societal factors may affect an educational system in any number of ways. Factors such as population size and structure, family and social organization, working patterns, patterns of

(continued next page)

sions should be made. Plato and Aristotle believed that education was so important it should be monopolized and controlled by the state. Rousseau, on the other hand, was opposed to all formal schooling, believing that nature was the best teacher. John Stuart Mill took a middle position. Strongly in favor of public support for education, he feared the consequences of public control over education. Mill said, for example:

> The objections which are urged with reason against State education do not apply to the enforcement of education by the State, but to the State's taking upon itself to direct that education; which is a totally different thing. That the whole or any large part of the education of the people should be in State hands, I go as far as anyone in deprecating. All that has been said of the importance of individuality of character, and diversity in opinions and modes of conduct, involves, as of the same unspeakable importance, diversity of education. A general state of education is a mere contrivance for molding people to be exactly like one another; and as the predominant power in the government—whether this be a monarch, a priesthood, an aristocracy, or the majority of the existing generation.[4]

Writing in 1859, Mill expressed an attitude toward public education that was greatly at odds with the one then prevailing in the United States, where the crusade for public schools was at its height. If Mill were to write these words today, however, he would find a more receptive audience. For today, serious question is being given to the question of whether or not education should be treated as a public or a private good.

In the United States, education has traditionally been treated as if it were a public good.* Most educational decisions have been made in the political arena; and most educational activities have been supported, if not financed, with public funds. This practice of treating education as a public good reflects, in part, the traditional American belief that education plays an essential societal role. Contrasting the attitude of Americans towards education with that of Europeans, Alexis de Tocqueville, the well-known commentator on American society, noted in 1831:

> Everyone I have met up to now, to whatever rank of society they belong, has seemed incapable of imagining that one could doubt the value of education. They never fail to smile when told that this view is not universally accepted in Europe. They agree in thinking that the diffusion of knowledge, useful for all peoples, is absolutely necessary for a free people like their own, where there is no property qualification for voting or for standing for election. That seemed to be an idea taking root in every head.[5]

The public benefits that Americans have associated with education have changed over time and in different historical circumstances. In the earliest years of American history, education was, for example, considered essential for the survival of the new democratic Nation. Later, with the need to acculturate immigrants into society and to unite a divided Nation in the aftermath of the Civil War, it was considered the means for building a Nation of citizens. At the turn of the century, education was expected to train and socialize American youths for participation in a modern, industrialized society. More recently, Americans have

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social and economic mobility, the availability of leisure time, and personal resources all serve to establish who, in a society, will be educated. Similarly, the level and configuration of social organization determine, in part, the kinds of institutions that are adopted to perform the educational function; while the level of economic, social, and cultural development determine, in part, the idea of what, in a given society, constitutes literacy.

[4] John Stuart Mill, *On Liberty*.

*Public goods refer to those goods whose benefits are available to everyone and from which no one can be excluded. These goods will not be produced privately, and thus they must be produced by government. There are only a few pure public goods, one example being national defense. There are, however, some goods, like education, that are impure public goods. These combine aspects of both public and private goods. Although they serve a private function, there are also public benefits associated with them. Impure public goods may be produced and distributed privately in the market or collectively through government. How they are produced is a societal choice of significant consequence. If decisions about impure public goods are made in the market, on the basis of personal preferences alone, then the public benefits associated with them may not be efficiently produced or equitably distributed. Edwin Mansfield, *Microeconomics Theory and Applications*, New York, 1970.

[5] Alexis de Tocqueville, *Journey to America*, translated by George Lawrence, J. P. Mayer (ed.), Anchor Books, 1971.

seen in education the solutions to some of the Nation's thorniest social problems.

To guarantee that these public benefits would be provided, Americans established a whole range of public institutions—elementary and secondary schools, 4-year and community colleges, libraries, and museums. Moreover, to assure that private educational institutions served public goals, they supported and regulated them.

Americans were able to treat education as a public good because, having similar needs and agreeing essentially upon the rules by which they lived, they were able to agree upon the kind of education that they wanted to pass on from one generation to the next.[6] Given this consensus, there was little conflict between what was a public or a private educational interest, or between what was a local or national educational goal.

Although highly institutionalized, the American educational system has been quite successful in adapting to meet the changing needs of society. It has been transformed from a system designed to meet the needs of an agrarian society to one tailored to meet the needs of an urban, industrialized society. It has been changed, moreoever, from a system structured to meet the educational needs of a privileged few, to one more structured to meet the diverse and sometimes conflicting needs of a growing and heterogeneous population.

Today, however, society is undergoing changes that may affect the nature of the system itself. Some of these changes originate within the educational system; others stem from the profound changes taking place in the larger social environment. Among these developments are:

- an increase in the level of education that individuals need to participate effectively in society;
- an extension of the period of time during which individuals can and need to be educated;
- an increase in the diversity of the educational clientele and thus an increase in the diversity of the demand for education;
- a decline in the public resources available for education, resulting in part from:
  - an increase in the cost of producing education,
  - a questioning of the public benefits associated with education, and
  - a loss of confidence in the institutions providing education;
- the emergence of new institutions that, under new circumstances, find it profitable to market education; and,
- the development of the new information technologies that allow educational institutions to provide specialized services to specific sectors of the market.

These developments, taken together, will have a major impact on the educational system and on the institutions that have traditionally been responsible for providing educational services. Taking advantage of the developing market for special kinds of educational services, new profitmaking institutions are emerging to provide education. To compete in this growing and increasingly segmented market, many traditional educational institutions may have to curtail some of the services that they provide, retaining only those that have the greatest economic and political return. Changes such as these are, in fact, already occurring in almost all sectors of the educational system.

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[6] Rush Welter, *Popular Education and Democratic Thought in America* (New York: Columbia University Press, 1962); David Tyack and Elisabeth Hansot, "Conflict and Consensus in American Public Education," *America's Schools: Public and Private, Daedalus,* summer 1981.

Elementary and Secondary Education

Public Schools

The traditional American belief in the public virtues of education is nowhere better illustrated than in the historical commitment to a system of public schooling. It is highly symptomatic, therefore, that today serious questions are being raised about whether or not elementary and secondary education would be best served if it were provided through the mechanism of the market.

A legacy of the past, the public school system is a unique and typically American institution. For, while educational institutions are publicly supported in many societies, in no other country have they been established with such deliberate purpose and public expectation or been conceived of as being such an integral part of the political, social, and economic order.

Clearly recognizing the important role that education could play in building a nation, the Founding Fathers did not leave its development to chance. They strongly advocated public support for schooling.[7][*] In fostering education, however, they made little distinction between its public and private aspects. If American youth were provided with the knowledge necessary to preserve their liberties, all schooling, it was believed, would serve the public interest.

The American commitment to public schooling grew in the wake of the Civil War. This commitment was so intense that it gave rise to a national crusade to establish public schools. Concerned about the problems of reconstruction in the South, the influx of Catholic immigrants, and the advent of industrialization in the North, Americans saw public schooling as a way of preserving the social, economic, and political system. By educating American youth in common, public schools, they hoped to inculcate them with a common set of patriotic, Protestant, and republican values.[8]

With the industrialization and urbanization of American society, it was expected that schooling would serve not only to prepare American youth for a common political role as citizens, but also to prepare a growing number of people from increasingly different social, economic, and ethnic backgrounds for an increasingly differentiated set of economic roles. To perform this economic function, the public schools were restructured in accordance with business principles.[9][*] Vocational education and guidance were introduced as part of the educational curriculum. Assuming that the majority of Americans would be working at industrial jobs, educators believed that vocational education would serve not only the best interests of the individual, but also the best interests of society.[10]

In the period that followed World War II, support grew for the view that the social and economic well-being of the Nation depended not only on the efficient production of goods and services, but also on their equitable distribution. As a growing and upwardly mobile school-age population began to compete for educational rewards, the question of distribution and access became central to the educational system.[11] This new emphasis on equity had a profound effect on the American school system. For, in addition to fulfilling a political and an economic function, the American public school system was increasingly called upon to serve as an agent of social change.[12]* To implement the extensive goals provided for in the legislation of this period, the Federal Government became increasingly involved in the funding, operation, and administration of school activities.[13]

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[7] Bernard Bailyn, *Education in the Forming of American Society* (New York: W. W. North, 1980); Lawrence A. Cremin, *Traditions in American Education*, Basic Books, Harper 1976.

[*] There was very little formal schooling in America until after the Revolutionary War. Throughout colonial times, education was conducted informally in the home and in the church. The formal schooling that did exist was of marginal significance, serving only those who were training for specific roles.

[8] Welter, op. cit.; Tyack and Hansot, op. cit.; Robert A. Carlson, *The Quest for Conformity: Americanization Through Education*, John Wiley & Sons, 1975; " Public Education as Nation Building in America: Enrollments and Bureaucratization in the American States, 1870-1930," *American Journal of Sociology*, vol. 85, No. 3, November 1979.

[9] David K. Cohen and Barbara Neufeld, "The Failure of High Schools and the Progress of Education," *America's Schools: Public and Private, Daedalus*, summer, 1981; Tyack and Hansot, op. cit.; and Sol Cohen, "The Industrial Education Movement, 1906-1917," *American Quarterly*, spring 1968, pp. 95-110; Martin Trow, "The Second Transformation of American Secondary Education," *International Journal of Comparative Sociology*, vol. 7, 1961.

[*] To unify the school system and to make it more efficient, educational reformers began to standardize textbooks and curriculum, to grade classes, to train teachers in approved methods, and to improve the supervision of the schools. Businessmen played an important role in bringing about these changes. Viewing education as a public good, businessmen looked to the public schools to expand wealth and improve productivity. Concerned about strikes, labor turnover, and increasing worker absenteeism, many businessmen hoped that public schooling, and vocational education, in particular, would socialize a growing number of immigrant youths for the workplace.

[10] Ibid.

Status of the American Public School System

The American public school system is a relatively large enterprise. In the school year 1978-79, it included 16,014 school districts in which there were 53,192 elementary schools, 12,020 middle schools, and 16,639 secondary schools including high schools[14] (see table 13).

Public education accounts for a significant portion of public expenditures. In 1977-78, $84.9 billion was spent on elementary and secondary education. Of this total the Federal Government contributed about $8 billion, or about 9.5 percent[15] (see table 14).

Table 13.—Number of Public Elementary/Secondary Schools and Estimated Percentage Distribution, By Level of Instruction and Grade Span Served: School Year 1978-79

Level[a] and grade span	Number	Percentage distribution
Total schools	**87,006**	**100.0**
Elementary schools[b]	53,192	61.1
Preprimary only	902	1.0
Preprimary to 2nd	1,052	1.2
Preprimary to 3rd	2,215	2.6
Preprimary to 4th	2,920	3.4
Preprimary to 5th	8,116	9.3
Preprimary to 6th	25,618	29.4
Preprimary to 7th	790	0.9
Preprimary to 8th	7,229	8.3
4th to 6th	746	0.9
Other spans with highest grade preprimary to 6th	3,604	4.1
Junior high or middle schools	12,020	13.8
5th to 8th	928	1.1
6th to 8th	2,888	3.3
7th to 8th	2,132	2.4
7th to 9th	3,790	4.4
Other spans with highest grade 7th to 9th	2,282	2.6
Secondary schools including high schools	16,639	19.1
7th to 12th	4,045	4.6
8th to 12th	417	0.5
9th to 12th	7,584	8.7
10th to 12th	2,813	3.2
Other spans with highest grade 10th to 12th	1,780	2.1
Combined elementary/secondary schools (preprimary to 12th)	1,145	1.3
Schools not classified by lowest and highest grade[c]	4,010	4.6

[a] Level of school is a classification by highest grade served. Elementary includes schools with no grade higher than 8th. Junior high and middle schools have no grades higher than 7th, 8th, 9th and no grade lower than 5th, 6th, or 7th. Secondary schools have as the highest grade 10th, 11th, or 12th.

[b] Lowest grade of elementary schools may include prekindergarten, kindergarten, or 1st grade.

[c] Schools in this category have grade spans that are unspecified, ungraded, or unclassified.

NOTE: These national estimates are based on information reported in 1978 by all States except California, Georgia, and Massachusetts. Each category was inflated equally to represent a known national total of 87,006.

SOURCE: U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD) 1978-79 Survey, unpublished tabulations.

Measured by the goal of providing universal public education, the public school system has been a reasonable success. Americans today are better educated than ever before. Moreover, many of the barriers to education that once served to limit an individual's access to the socioeconomic benefits of society have been removed. However, despite the central role that the public school has played in American society and the numerous accom-

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[11] Cohen and Neufeld, op. cit.

[12] Cohen and Neufeld, op. cit.

*This was, for example, the goal of the Elementary and Secondary Educational Act of 1965, the most comprehensive and significant educational legislation passed during this period. Conceived of and marketed not only as an education bill, this act was a major piece of antipoverty legislation. Between 1958 and 1978, for example, Federal expenditures on education increased sixfold. The Federal Government became so involved with the operational activities that it presented an unprecedented challenge to the authority of the States and localities to control public school programs.

[13] Steven K. Bailey, "Political Coalitions for Public Education," *America's Schools: Public and Private, Daedalus*, summer 1981; Tyll van Geel, *Authority to Control the School Program* (Lexington, Mass.: Lexington Books, 1976).

[14] *Digest of Education Statistics*, National Center for Education Statistics, May 1980.

[15] Ibid.

Table 14.—Revenue and Nonrevenue Receipts of Public Elementary and Secondary Schools, By Source, 1977-78 (amounts in thousands of dollars)

Total revenue and nonrevenue receipts	Revenue receipts							Nonrevenue receipts
		Federal		State		Local and other		
	Total	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	
$84,969,058	$81,440,326	$7,699,042	9.5	$35,005,584	43.0	$38,735,700	47.6	$3,528,732

SOURCE: U.S. Department of Education, National Center for Education Statistics, *Digest of Education Statistics, 1980.*

plishments that can be attributed to it, the American public is becoming increasingly disenchanted with public schools (see fig. 3).

Several explanations have been suggested for this loss of support.[16] It has been suggested, for example, that the school system has suffered from:

- a general loss of confidence in and support for all public institutions;
- the association of public schooling with unpopular social policies such as busing and desegregation;
- the decline in overall school performance as measured by traditional indicators such as test scores;
- the public backlash against what appears to be the unprofessional behavior of some unionized teachers;
- the concern about inflation and increased taxation;
- the dissatisfaction with American youth and their culture; and;
- the disintegration of the political coalition that has traditionally provided support for the public schools.

The loss of a common base of support for the public schools has had a negative effect on the conditions under which they have had to operate. Forced to appeal for their support to a number of increasingly distinct and diverse interests, the public schools have had to take on a multitude of new and often conflicting tasks at a time when they face the prospects of reduced economic and human resources.

Future of the American Public School System

Many educational commentators have argued that if public schools are to survive, educators will have to adopt a more limited set of goals, which, although less ambitious, will be more likely to gain public support.[17] Success in this endeavor will depend, to a large degree, on future societal developments. The prognosis according to educational futurists is not particularly good. Instead of providing the basis for a national consensus in support of public schools, demographic, economic, and societal trends may, in fact, serve to intensify the centrifugal tendencies already at work in the educational system.[18]

Forecasts of demographic trends suggest, for example, that Hispanics, Asians, and other cultural groups with specialized needs will soon comprise a major portion of the school population. Moreover, the increase in the number of school-age children living with a single parent or two working parents will force schools to provide more supervision and socialization. Instead of cutting back on their educational activities, schools will have to cater to a growing variety of educational needs.

Economic forecasts also cast doubts about the future of public schools. If economic growth rates remain slow, and inflation and interest rates continue to be high, the schools will be in intense competition with other service sectors for reduced human and economic resources. Faced with the loss of personal income because of increased levels of inflation

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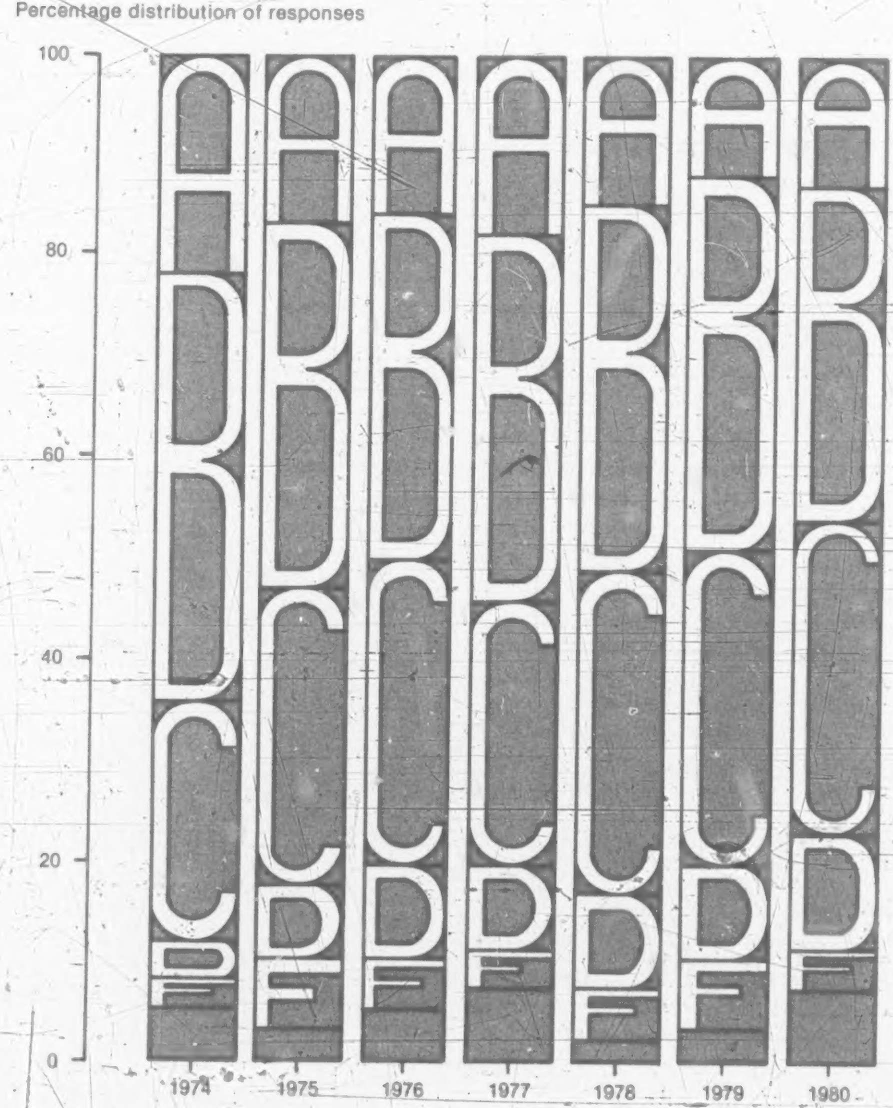
[16] Michael W. Kirst, "Loss of Support for Public Secondary Schools," *America's Schools: Public and Private, Daedalus* summer, 1981; Bailey, op. cit.; Patricia Albjerg Graham, "Literacy: A Goal for Secondary Schools," *America's Schools: Public and Private, Daedalus,* summer 1981.

[17] Graham, op. cit.; Tyack and Hansot, op. cit.; Bailey, op. cit.

[18] Christopher Dede, *Potential Clients for Educational Services Delivered by Information Technology,* unpublished report prepared for the Office of Technology Assessment, March 1981.

Figure 3.—Quality of the Public Schools: Opinions of Parents With Public School Children

"Students are often given the grades A, B, C, D, and F (FAIL) to denote the quality of their work. Suppose the public schools themselves, in this community, were graded in the same way. What grade would you give the public school here—A, B, C, D, or F?"



SOURCE: "The Condition of Education," 1981, National Center for Education Statistics.

and high energy costs, the American public is, in general, less willing to finance educational expenditures through additional taxation. This reluctance is likely to increase as the number of families with school-age children declines and the number of those beyond child-bearing age increases.

Faced with their own problems of increasing costs and shrinking resources, Federal and State governments will be unable to fill in the financial gaps. Continued high inflation will also reduce the economic resources available for public schools. Because of inflation, the costs of education are increasing twice as fast as the rate of increase of revenues for education. Thus, in 10 years, if inflation continues at its present rate, eduational institutions will have only one half of the revenues (in real terms) that they have now.[19]*

The problem of scarce economic resources will be matched by a problem of scarce human resources. The problem of human resources is, however, not so much a problem of numbers—for the supply of teachers may very well exceed the demand—as it is a problem of quality. A decline in highly qualified educators is already evident. Few entering-college freshmen select a career in teaching, and, more significantly, those that do are generally among those who have the lowest academic qualifications.[20] Increasingly, there are fewer incentives for well qualified individuals to enter the teaching field.

Given the financial problems facing schools, a career in teaching is no longer considered to be secure. Given the loss of public support for education, a career in teaching is less likely to provide the rewards of public status or personal esteem. Since teaching salaries are not competitive with those in private industry, many of the most highly qualified teachers—especially those with qualifications in math and science—will give up teaching to sell their skills on the open market. Well qualified women—a traditional source of high quality educators—are particularly likely to seek out the wider range of employment opportunities now available to them.[21]

Private Alternatives to Public Schools

Conflicts over public and private control of education have always existed. While reserving for itself the dominant role in educational matters, government in the United States has always recognized that private individuals have an interest in the outcome of educational policy decisions. It has generally been recognized, for example, that parents have certain rights—based on notions of liberty and privacy—in determining the education of their children.

In order to take into consideration both public and private concerns, the responsibility for educational policy and administration has traditionally been allocated to the States and to local jurisdictions where, given more homogeneous populations, public decisions about education would be most likely to reflect private concerns.[22] Parents whose needs were not adequately met by public education were allowed the option of sending their children to private schools.

This arrangement, which served in the past to reconcile public and private educational needs, is thought to be increasingly less effective, as the assumptions upon which it is based become increasingly less realistic. For example, as the Federal Government assumed more authority over educational policy, the character of schooling has become less subject to local influence and control. Moreover, since many local communities are no longer comprised of homogeneous populations, there is also less likelihood that public decisions—even when they are made at the local level—will be synonomous with private, individual needs.[23]

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[19] Ibid; Kirst, op. cit.

*While all public schools are likely to suffer a loss of economic resources, the problems created will be greater in some areas than in others. The urban schools in the Northeast will be the most seriously affected because the recent migration of people away from the area has caused a significant loss of taxable resources. The economic problems in the area of the sunbelt, on the other hand, will be ameliorated by an influx of population which will increase the area's tax base.

[20] "Introduction," *America's Schools: Public and Private, Daedalus*, summer 1981; J. Myron Atkin, "Who Will Teach in High School," *America's Schools: Public and Private, Daedalus*, summer 1981; Dede, op. cit., 1981.

[21] Atkin, op. cit.

[22] Van Geel, op. cit.

Conflicts over public and private educational interests have grown along with the enhanced importance of education in American society. Because education has come to be regarded as the essential means for gaining access to socioeconomic rewards, individuals now believe that they have more of a stake than ever before in the outcome of decisions about it. In this sense, individual interests are likely to diverge from those of government. For whereas government is committed to providing equal access to educational opportunities, an individual, if he is to compete successfully for socioeconomic rewards, must gain an educational advantage.[24]

Private dissatisfaction with public decisions about education has led some people to seek alternatives to public school education. Traditionally, that alternative has been the private or independent school. Although such schools have always provided a considerable proportion of all elementary and secondary education, they are today experiencing a revival of interest.[25]

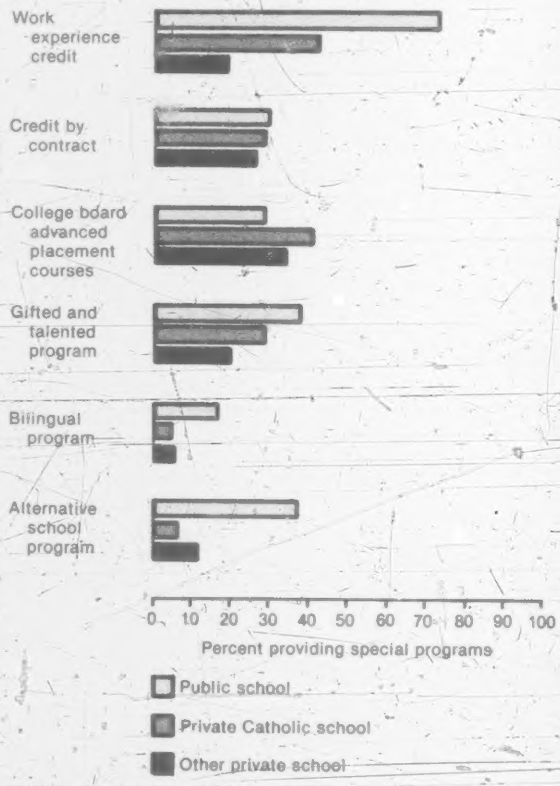
There are today in the United States 14,300 private elementary and 4,700 private secondary schools.[26] Of these schools, 85 percent are religiously affiliated, and 65 percent of these are associated with the Roman Catholic Church.[27]

Private schools provide educational services to one out of every nine students. Enrollment in the fall of 1978 totalled 5,000,158. Having declined substantially since the 1960's, enrollment is more stable today. Declines in enrollment have been greatest in Roman Catholic schools, a considerable number of which have closed due to lack of resources.[28]

Unlike public schools, private schools are relatively independent of public control. Accountable to a governing board of trustees, they are free to determine their own objectives and the means by which they pursue them. Although the types and levels of courses vary significantly between schools, private schools are generally distinct from public schools inasmuch as they offer less work experience, less bilingual education, and less alternative schooling (see fig. 4).

Demand for private school education appears to be also related to the quality of public school alternatives. Private school enrollments

Figure 4.—Secondary Schools Providing Special Programs



SOURCE: "The Condition of Education," 1981, National Center for Education Statistics.

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[23] Ibid.

[24] Cohen and Neufeld, op. cit.

[25] William A. Oates, "Independent Schools: Landscape and Learnings," *American Schools: Portraits and Perspectives, Daedalus*, fall 1981; James Coleman, "Private Schools, Public Schools, and the Public Interest, *The Public Interest*.

[26] *Digest of Educational Statistics*, op. cit.

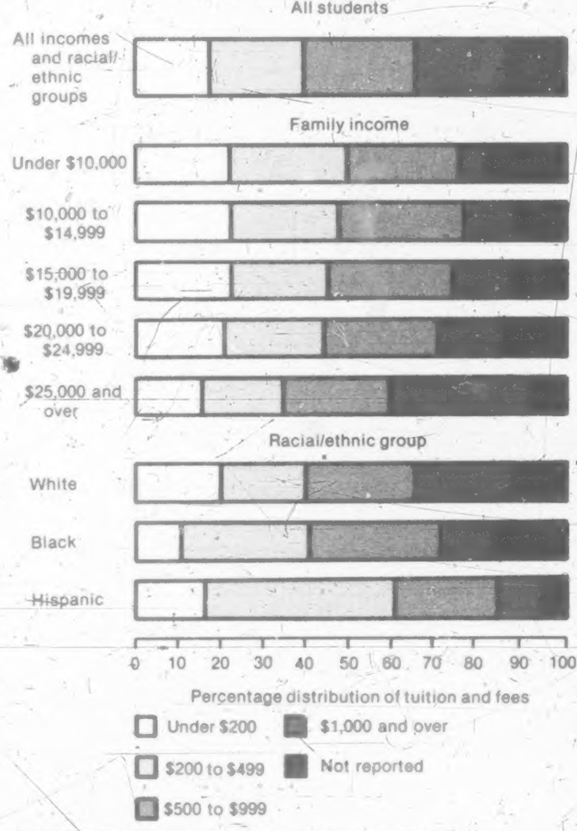
[27] Oates, op. cit.

[28] *Digest of Educational Statistics*, op. cit.

are highest in those areas where public schools are experiencing the most severe problems. Private school enrollments are highest in the metropolitan cities of the Northeast, where 21.3 percent of all students attend private schools. Of all students in the North Central Region, 11.5 percent attend private schools as compared with rates between 7.8 and 7.9 percent for the West and the South. The lowest rate of private school attendance, 2.8 percent, is in the nonmetropolitan areas of the West.[29]

Demand for private school education is also related to the ability of individuals to pay for it. Levels of family incomes distinguish those students who are enrolled in private schools from those who are enrolled in public schools, and those students who attend religiously affiliated schools from those who attend the more expensive, unaffiliated schools (see fig. 5). While 21 percent of all public school students come from families with annual incomes of $25,000 or more, as many as 37 percent of all private students do. And, whereas 35 percent of the students attending religiously affiliated schools come from this income bracket, there are over 56 percent in unaffiliated schools who do. Students coming from families of this income level are also among those who are most likely to spend $1,000 or more on tuition and fees.[30]

Figure 5.—Private Elementary/Secondary School Tuition and Fees by Family Income Racial/Ethnic Group



SOURCE: "The Condition of Education," 1981, National Center for Education Statistics.

Because cost is a major factor inhibiting individuals from choosing private alternatives to public education, much of the discussion about public and private school education has focused on public policy options that call for public subsidization of private educational costs. The options that have been most frequently proposed and considered are the tuition tax credit and the educational voucher.

The educational voucher has generated such diverse interest and support in part because it is a general concept for which there is no one particular model. Included under the rubric of an educational voucher could be, for example, any sum of money (or financial credit, such as a tax credit) provided by any class or group of individuals for the purpose of buying any type of educational service in the market. The nature and potential impact of any particular voucher would vary, therefore, according to who receives how much money, from whom, under what conditions, and for what purposes.

Although not a new idea, the educational voucher has only recently become a topic of public debate in the United States. Interest in the voucher has grown with the public's increased disillusionment with the public school system. Initially championed during the 1960's as a way of providing aid to parochial schools and of circumventing desegregation rulings, during the Nixon administration, it was proposed as a way of providing educational assistance to disadvantaged groups. Today it is receiving attention, if not the support, of a wide variety of diverse interests each of which seeks to bring about structural changes in the educational system.

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[29] *The Condition of Education*, 1981.

[30] Ibid.

Although many different versions of the voucher idea have been proposed, all educational voucher proposals have one essential element in common. They all assume that education should be treated as a private, rather than a public good. While acknowledging that education merits public support, voucher advocates would generally argue that the present system of public schools, responsible as it is to a political body, produces poor-quality education. They see the voucher as a way of allowing government to continue to support education without having, at the same time, to sacrifice quality and diversity to public conformity. They argue that if parents were to be given public vouchers with which to buy educational services in the marketplace, then schools, forced for the first time to compete for students, would have not only to improve the general quality of their educational services but also to tailor these services more specifically to meet the needs of their clientele.[31] By providing diversity and accountability as well as the encouragement of high-quality education, the educational voucher would, according to its proponents, benefit both individuals and society.

Voucher proposals have been strongly criticized on the grounds that, once implemented, they would recreate many of the same problems that the public school was established to rectify. In encouraging diversity, critics argue, the voucher system may exacerbate socioeconomic disparities and cleavages. They contend that a voucher system would discriminate against the poor, because in an unregulated market, educational services would be distributed according to one's ability to pay. Opponents are concerned, moreover, that vouchers might be used, as they have in the past, to facilitate segregation.[32]

Acknowledging these problems, some proponents have suggested that the voucher be regulated to prevent them.[33] To assure open access to private schools, regulations have been proposed, for example, that would set limits on tuition and that would guarantee that a certain proportion of the student bodies of all schools be selected at random. However, a basic problem with the regulated educational voucher would be that the more complex the regulations, the less likely that individuals participating in the system would be able to take full advantage of whatever benefits it offers. This could be one reason why the proposals for the regulated vouchers have received less public attention and support than those for unregulated ones.

In 1978, a tuition tax credit bill was approved in the House of Representatives, and gained 41 new votes in the Senate. In 1980, the Republican Party supported the voucher concept in its party platform, and the concept has clearly gained in popularity. Most recently, the Reagan administration has proposed its own tax tuition plan. Dissatisfied with the private benefits of the public school system, more and more Americans regard the voucher as a way of reducing the costs of educating their children in private schools.[34]

Designed as it is to cater more specifically to particularistic needs, the voucher is an idea that should be well received in the segmented educational market that will characterize the future. Public pressure to adopt some kind of a voucher system will probably increase.

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[31] George La Naoue, *Educational Vouchers, Concepts and Controversies,* Teachers College Press, 1972.

[32] Ibid.

[33] Ibid.

[34] Jean Rosenblatt and Hoyt Gimlin, "Tuition Tax Credits," Editorial Research Reports, Aug. 14, 1981.

University and the Four-Year Colleges

As semiautonomous communities of faculties and students, universities are organized for learning and for research. Although they still retain many of the institutional features of their medieval heritage—a name, a central location, a degree of autonomy, a system of lectures, a procedure for examinations and degrees, and an administrative structure organized around faculties—universities have evolved over time to meet changing societal needs.[35]

American colleges and universities were able to monopolize the field of higher education because they were relatively autonomous, economically self-sufficient, and comprehensive in scope—capable of serving the multiple goals of higher education.[36] Today, they no longer enjoy these advantages. As knowledge has increasingly come to be viewed as an important economic resource that can be bought and sold in the market, colleges and universities, faced with increasing costs and with competition from private, profitmaking institutions, have had to consider undergoing some radical changes.

Public Role of Higher Education

Although originating in the private sector,[37] * American universities have become semi-public institutions, regulated and supported, to a large extent, by government. This development occurred near the end of the 19th century, when Americans began to regard colleges and universities as having a unique societal role.[38] Unlike institutions of elementary and secondary education, which were expected to prepare the general population of youth for adult roles in society, institutions of higher education were expected to recruit those who qualified for leadership positions. And, whereas elementary and secondary education schools were designed to transmit the general, or popular, culture from one generation to the next, colleges and universities were expected to transmit the total knowledge base of society. They were to be responsible, moreover, not only for the transmission of knowledge, but also—through the pursuit of research—for its creation. Believed to have a special understanding of society, universities were called on to bring about its improvement.[39] *

Two events—the land-grant movement and the alliance during World War II between the universities and the Federal Government—strongly influenced this development, giving the American university a distinct character. Involving the university in the daily life of the Nation, both of these events served to reinforce the public aspect of the university's role and to enhance the public's involvement in the affairs of the university.

Democratic and populist, the land-grant movement called on the universities to extend the benefits of education to all segments of society. Responding to the Nation's rapid industrial and agricultural development, it called on the universities, moreover, to expand beyond their traditional role of training gentlemen as preachers, lawyers, and doctors, and—through applied research—to develop the more practical applications of education. Provided for under the Morrill Act of 1862,[40]* land-grant colleges, open to children of all backgrounds were established to provide education in fields such as agriculture, engineering, home economics, and business administration. Unlike the traditional colleges, the land-grant colleges were not isolated communities. Through their agricultural experiment stations and their service bureaus, their activities were designed to serve the State.[41]

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[35] Clark Kerr, *The Uses of the University* (Cambridge, Mass.: Harvard University Press, 1972).

[36] Edward Shils, "The Order of Learning in the United States From 1865-1920: The Ascendency of the Universities," *Minerva*, vol. xvi, No. 2, summer 1978.

[37] Shils, op. cit; and Martin Trow, "Elite Higher Education: An Endangered Species?" *Minerva*, vol. xiv, No. 3, autumn 1976; Ernest L. Boyer and Fred M. Hechinger, *Higher Learning in the Nation's Service* (Washington, D.C.: The Carnegie Foundation for the Advancement of Teaching, 1981).

*The first universities to be established in the United States followed the traditional European model. Serving primarily the wealthier members of society, they were specifically established to educate youth for leadership positions in the fields of theology, law, and education.

[38] Shils, op. cit.

[39] Ibid.

*American colleges and universities were particularly well suited to play the role prescribed for them. Bringing together faculty members from all disciplines, they were unique centers of intellectual stimulation. The income they derived from teaching made them economically self-sufficient. And because their work was not circumscribed by practical necessities, faculty members were free to work on basic research in areas of their own intellectual interest. Notwithstanding a growing focus on research, the multidisciplinary nature of the university prevented it from becoming limited in scope and helped to foster a public belief that the pursuit of knowledge was, in and of itself, an important societal goal and one that the colleges and universities were alone capable of achieving.

Although the land-grant movement established the Federal Government's interest in higher education and served to legitimate the university's involvement in public affairs, there was no significant interaction between Government and the academic community until World War II, when several major universities were enlisted to conduct research for national defense. This wartime collaboration established a precedent by which the Federal Government began to look to the universities for help in executing national goals. In exchange for its assistance, the Federal Government provided the academic community with financial aid.[42]* An increasingly important source of funding, the Government came to exert a considerable influence on university affairs.[43]*

While continuing to support research, the Federal Government, in the late 1960's, also began to provide funds to assure that all qualified students would have access to higher education.[44]* In fiscal year 1978-79, the Federal Government spent approximately $14 billion to meet these goals.[45] Today, nearly 40 percent of all students receive Federal aid, and 75 percent of all university expenditures for scientific research are federally funded.[46]

Measured in accomplishments, it is clear that the alliance between Government and the university has been quite successful. American universities have been responsible for many of the Nation's most significant achievements. Since World War II, for example, American scholars have received more than half of all the Nobel Prizes awarded for science. And American research dominates the world's scientific and technical literature, accounting for approximately 40 percent of the articles written each year.[47] Moreover, the American university system has been remarkably successful in providing extensive and varied educational resources to a broadly based and increasingly diverse clientele.

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[40] The Morrill Act of 1862.

*This law provided land to the States, the proceeds of which were to be used to teach in the fields of agriculture and mechanical arts. Subsequent legislation provided Federal financial support for research and the operation of the land-grant colleges.

[41] Kerr, op. cit.

[42] Kerr, op. cit.; Patrick M. Morgan, "Academic and the Federal Government," *Policy Studies Journal*, vol. 10, 1981; D. Bok, "The Federal Government and the University," D. Bok, *The Public Interest*, winter 1980.

*Federal involvement in higher education increased markedly after World War II. By 1960, the academic community was receiving about $1.5 billion from the Federal Government, 100 times as much as it had received 20 years before. Most of these funds were spent on research-related activities, and were channeled to a limited number of universities and to a limited group of departments within universities.

[43] Kerr, op. cit.

*Federal funding was used to support research in about 10 major universities. Most funds were spent for research in the physical and biomedical sciences and in engineering. Only about 3 percent were used to support research in the social sciences, and almost nothing was spent for the humanities. University decisions to accept Federal funds for research occurred outside of the normal academic decisionmaking process, and often determined how the universities would distribute their own funds and facilities.

[44] Morgan, op. cit.

*The Civil Rights Act of 1964, the National Education Act of 1965, and the Educational Amendments of 1972 provided the legislative basis for increased Federal involvement in academic affairs. In this legislation, the Federal Government endorsed the view that higher education was a vital national resource and one to which all Americans should have equal access.

[45] Sloan Commission on Government and Higher Education, 1980 Report.

[46] Morgan, op. cit.

[47] Boyer and Heckinger, op. cit.

Status of American Colleges and Universities

Today there are in the United States approximately 1,957 4-year colleges and universities, 549 of which are public and 1,408 private. Reflecting the pluralistic nature of American society, they include a wide variety of institutions. All together they enroll about 4,115,000 full-time students.[48] Over the past 10 years, institutions of higher education have expanded rapidly in size, in number, and in the kinds of services that they render.[49]* During the same period, higher education has been made available to a much broader section of the population.[50]*

The expansion of colleges and universities to meet the growing demands for education has, however, affected their future viability. American colleges and universities are, for example, no longer semiautonomous institutions. Heavily supported and regulated by government, they have lost considerable control over some of of their own internal affairs. In recent years, the Federal Government has come to determine such issues as who should be taught what, by whom, and how.[51]

The American university is, moreover, no longer economically self-sufficient. Funds derived from teaching can no longer be used to subsidize university research. In fact today the reverse is true. Revenues from research now pay the overhead for many of the university's more traditional functions. As a result, more than ever before, departments are being designed to suit the needs of research, and faculty members are being selected more on the basis of their ability to attract research contracts and grants than on their ability to teach or even to publish.[52]

Once the undisputed center of research efforts in the United States, American universities are today competing strenuously with one another and with business and governmental research institutes for money and resources. In the present economic and educational climate, most universities are finding it difficult to compete. The cost of equipment for advanced scientific research is extremely expensive to buy and to maintain.[53] Faculty members, drawn by the superior research opportunities and financial benefits offered by private firms and government, are leaving the universities and taking their research teams with them.[54]

To make themselves more financially independent, many universities and colleges have begun to sell their educational services to new clients and to deliver them in new forms. In an effort to capture some of the growing adult market for education, universities, as early as 1963, began to develop programs of continuing education. Many colleges and universities now offer degree courses through correspondence programs. To compete more effectively with proprietary educational institutions, several colleges and universities have shifted the focus of their curricula from the arts, culture, and leisure activities to vocational needs. Taking advantage of some of the new information and communications technologies, several universities have, moreover, begun to broadcast courses over cable TV and to package instructional materials on video disks and video cassettes for sale to businesses or to other educational institutions.[55]

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[48] *The Condition of Education*, op. cit.

[49] Ibid.

*During the 1970's, the number of institutions of higher education increased by 241 percent, the number of students attending these institutions increased by 290 percent, and the number of degrees conferred upon graduates increased by 251 percent.

[50] Ibid.

*Increased access to institutions of higher education is indicated by the changed racial and ethnic composition of the student body. For example, the difference between the percentage of blacks in the total population and the percentage of blacks in the student body decreased significantly during these years. This changed composition of the student body can also be seen in the increase in the number of degrees that were conferred upon female and minority students.

[51] Bok, op. cit; Morgan, op. cit.

[52] Stephanic Yanchinski, "Universities Take To the Market Place," *New Scientist*, December 1981; Will Lepkowski, "Research Universities Face New Fiscal Realities," *Chemical and Engineering News*, Nov. 23, 1981.

[53] "Graduate Universities—A New Model," *Science*, December 1981.

[54] Lepkowski, op. cit.

[55] Patsy Vyner, *Telephone Survey on Use of Telecommunications Technologies at Post Secondary Institutions*, unpublished paper, 1982.

Operating more and more in the market sector, universities are also beginning to sell and to patent the results of their research.[56]* Many of these arrangements are being made with the cooperation of business. Moreover, several faculty members acting independently have joined with suppliers of venture capital to establish new companies in fields such as genetics and electronics.[57]*

If universities are to keep pace with their competitors in the profitmaking sector, it is clear that, given diminished Government funding, they will have to make some new financial arrangements with industry. This development has caused some concern within the academic community. Meeting in Rome, Italy, a number of biologists recently identified some of the issues that might arise if universities become deeply involved in commercial ventures. To preserve their proprietary rights, universities might, for example, begin to restrict the free exchange of information, a process upon which so many of the university's traditional functions depend. In an effort to preserve traditional values, some academics are now trying to develop guidelines for collaboration.[58]

Today, as the demand for knowledge and the cost of its generation increase, many colleges and universities are finding it more difficult to be all-purpose "multiversities."* Unable to obtain Government or industry funding, many small liberal arts colleges, for example, can no longer afford to pursue major research efforts. And many larger institutions have had to curtail some of their research departments. Others are beginning to shift their educational focus from one that emphasizes the liberal arts to one that prepares students for careers in a great variety of new and expanding technical, semiprofessional, and managerial occupations. This public/private development may have far-reaching consequences. If more and more colleges and universities begin to function as single-purpose organizations, they may find that they face much stiffer competition from the growing number of other single-purpose institutions now seeking to provide education in the marketplace.

Information and communication technologies have potential applications for all aspects of higher education. They can play an important role, for example, both in providing a liberal education as well as in training individuals for specific roles in society. They can serve, moreover, to facilitate research and the storing, retrieving and sharing of knowledge. Many of the ways in which the new technologies can be used will be of special interest to those universities which, in the face of shifting demands and shrinking resources, are searching for new ways to become more economically and socially secure.

They might be used, for example, to provide faculty support in routine and remedial learning situations. The need for such support is likely to increase in the future, given an increase in the costs of providing higher education, an increase in the number of college students who will come from minority backgrounds, an increase in number of adults seeking higher education, and an increase in the need for job retraining. Many colleges and universities are already using and developing new ways to apply information and communication technologies for these purposes. At North Carolina State University, for example, students and faculty members worked together to develop a successful video tape instructional program that teaches strategies for studying and learning.[59]

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[56] Lepkowski, op. cit.

*For example, Stanford University recently sold the design of their software chip of a music synthesizer, developed by one of their music professors, to Yamaha of Japan for \$700,000.

[57] "The Academic-Industrial Complex," *Science*, vol. 216, May 28, 1982.

*For example, Hoechst AG, a German pharmaceutical firm, recently provided \$70 million for the founding of a new department of molecular biology at the Massachusetts General Hospital. In exchange for this contribution, the Massachusetts General Hospital has agreed to grant Hoechst exclusive worldwide licenses to any patentable developments that result from company-sponsored research. Harvard Medical School has a similar agreement with E. I. du Pont de Nemours. In exchange for a \$5 million contribution to build a new genetics department, Harvard has agreed to grant Du Pont licenses to market any commercially useful research for which it has paid.

[58] Ibid.; and Yanchinski, op. cit.

*The term "multiversity" was coined by Clark Kerr. It refers to university communities where teaching and research activities coexist but are performed in and by different sectors of the university.

[59] *Telescan: The Digest of the Center for Learning and Telecommunications*, vol. 1, issue 1, October 1981.

The new technologies can also be used to extend the boundaries of the university to provide teaching facilities to those who would otherwise not have access to them. Many colleges and universities have, for example, joined with public broadcasting stations to broadcast college credit telecourses as part of a new Adult Learning Service to be coordinated nationally by the Public Broadcasting Services.[60] Members of the health community have, moreover, used video teleconferencing to provide continuing medical education to professionals throughout the country.[61]

Communication and information technologies can also be used to distribute scarce teaching and faculty resources across many campuses. Recognizing the potential for sharing,

Columbia University graduate students with allotted mainframe time are working at the consoles (top). Their work is cranked into their department's information and stored for further processing at the Unversity's Mainframe Computer Center several colleges and universities have formed consortia to advise and assist them in the use of media-based materials. A telecommunications task force was recently formed at the National Association of State Universities and Land Grant Colleges,[62] for example.

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[60] Ibid.

[61] James J. Johnson, "A Case Study: The Healthy Pulse of Medical Video Teleconferencing," *Satellite Communications*, May 1981, pp. 19-23.

While the use of computers in college and university teaching has traditionally been limited to the fields of math and science, it is increasingly being extended to other areas as well. Viewing computer literacy as an essential element of any general education, a number of liberal arts colleges, such as Harvard and Wells, now require that all of their students become familiar with the computer. Faculty members and students have experimented in using the computer to teach a wide range of courses including drama, English literature, psychology, and the classics.[63] Where students on a campus have ready access to computers, they are using them more and more not as an adjunct to, but as an integral part of their learning routines.[64]*

By facilitating sharing, information and communication technologies can help reduce the costs of and increase the resources available for performing university research. Networks to transmit data, voice, and video between universities are already being established. Some will provide individual users access to library resources and scientific data bases, while others, like Bitnet, will allow faculty members and students to communicate with their colleagues at different colleges and research institutions and provide an environment in which they can exchange ideas and information, and even coauthor papers.[65] By extending their traditional boundaries, the new information and communications technologies may help the universities to adapt to the changed needs and circumstances of an information age.

However, at the same time, and for many of the same reasons, they may also serve to undermine those aspects of the university that have traditionally set it apart from—and above—the rest of society. Semiautonomous communities' universities were expected to operate by a special set of rules and standards that would foster the development and the preservation of knowledge as a goal in and of itself. And members of the academic community, assumed to be loyal to these goals, were called on to serve as independent observers and critics of society. The widescale deployment of information technologies may affect the university's ability to perform this role. Increasingly linked to outside groups, the university community may be less able to function as an independent source of knowledge and as independent observer of society.

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[62] *Telescan*, May/June 1982.

[63] "The Wired University Is On Its Way," *Business Week*, Apr. 24, 1982.

[64] Ibid.

*Last year, for example, 60 of the entering students at Rensselaer Polytechnic Institute were given computers as an experiment to see how they would be used. Within a short period of time, these students became very comfortable with them, using them as extensively as students who had brought their own computers to campus.

[65] Bitnet Links Yale University, City University of New York, Columbia University, Princeton University, Rutgers University, Penn State University, Brown University, Boston University, and Cornell University.

Two-Year and Community Colleges

More than any other educational institution, the American community college has exhibited an ability and willingness to adapt rapidly to changing societal needs and circumstances. Experienced in reaching out to provide nontraditional services to new categories of students, community colleges may have a special need for, and be particularly suited to take advantage of, the new information technologies.

Community colleges emerged at the end of the 19th century to accommodate the growing number of youths who, seeking some kind of postsecondary education, either were unprepared for or could not find room in the traditional college and university system.[66] Some of these new colleges were extensions of secondary schools; others were 4-year colleges converted to 2-year programs. Referred to as junior colleges, they provided a general college curriculum designed to be transferrable to 4-year colleges and universities.

Today, as the change in their name suggests, community colleges offer a curricula more oriented towards the needs of local communities. Having continually added new functions as the need arose, community colleges now provide a wide variety of educational services. These include:[67]

- academic transfer programs;
- terminal general education programs;
- technical productive skills programs;
- life skill programs not related to employment;
- remedial programs;
- cultural, social, and recreational programs; and
- counseling.

To provide such a wide variety of programs and services, community colleges have employed untraditional organizational structures and educational techniques. Willing to adapt the institution to the needs of their students, they have followed policies of open admissions, made use of the special skills of nonacademic, part-time faculty members, allowed flexible scheduling, and offered courses off-campus in such remote places as nursing homes, prisons, and storefronts.[68]

Because of their organizational flexibility, their open-door policies, and their aggressiveness in recruiting new students, community colleges benefited more than any other institutions of higher education from the postwar baby boom and from the national emphasis during the 1960's on providing equal educational opportunities. Their growth during this period was phenomenal. Enrollment increased by 930 percent, and, on the average, one new college was established every week.[69]

Today there are 1,194 2-year community colleges in the United States, approximately three-quarters of which are publicly supported. Together they constituted in 1979 a $52-billion enterprise.[70] In 1980, community colleges enrolled 1,718 full-time and 2,733 part-time students, and employed about 87,000 full-time and 115,400 part-time faculty members. Although their distribution varies from State to State, they account for a substantial proportion of higher educational enrollments in all of them. In 1979, one-third of all students, and 27 percent of all full-time students were enrolled in community colleges.[71]

Although a large portion of all students of higher education are enrolled in community colleges, community college students differ significantly from those who have historically attended 4-year colleges and universities. As compared with those in the more traditional institutions, community college students are more likely to be older, registered part-time and in noncredit courses, to come from lower economic backgrounds and from minority groups, and to be in greater need of remedial instruction.[72]

Because of their demonstrated ability to adapt to change, and to attract new groups of students, community colleges, unlike most other institutions of higher education, are predicted to grow throughout the 1980's. Their future will, however, not be without problems.

As total levels of enrollment decline, all educational institutions will begin to compete for the same categories of students. Once alone in marketing their service to nontraditional groups of students, community colleges may, in the future, have to compete with high schools to provide adult basic education, with area vocational centers and proprietary institutions to teach vocational and commercial skills, with company-based training programs to provide job specific instruction, and with 4-year public and private colleges and universities to teach part-time and general education courses.[73]

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[66] For a history of community colleges, see Ralph R. Fields, *The Community College Movement* (New York: McGraw Hill, 1962).

[67] Clark Kerr, "Changes and Challenges Ahead for the Community College," *Community and Junior College Journal*, vol. 50, May 1980.

[68] Barbara Guthrie-Morse, "Agenda for the 80s: Community College Organizational Reform," *Community College Review*, spring 1981, pp. 0-8.

[69] D. W. Breneman and S. C. Nelson, *Financing Community Colleges: An Economic Perspective* (Washington, D.C.: The Brookings Institution, 1981).

[70] Ibid.

[71] Ibid.

[72] Ibid.

Community colleges will also have to compete with other institutions for scarce public resources. Charging relatively lower tuition fees than other institutions of higher education, community colleges are more dependent than most on public funding.

In recent years, State governments have assumed greater resposibility for and control over community college affairs.[74] In a period of increased costs and declining revenues, State policymakers, now responsible for a much broader area of educational activities, may have to reevaluate the rationale according to which educational funds are allocated. Community colleges may be particularly vulnerable in such a reevaluation, since there is less general recognition of, and no longstanding tradition to publicly finance, many of the functions that they perform.[75]

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[73] S. V. Martorana and Wayne D. Smutz, "State Legislation, Politics, and Community Colleges," *Community College Review*, winter 1980; S. V. Martorana and W. Cary McGuire, "Recent Legal Action Affecting Community Colleges: A National Survey," *Community College Review*, fall 1976.

[74] Breneman and Nelson, op. cit.

[75] Ibid.

Proprietary Education

Proprietary educational institutions are profit-seeking institutions that offer programs closely geared to preparing students to enter specific jobs and occupations. Over the years, four types of proprietary institutions have evolved, each appealing to a distinct educational market. They include trade and technical schools, licensed occupational schools (e.g., cosmetology and barbering), independent business schools, and home study schools. Most private and profit-seeking, preschool, elementary, secondary, and preparatory schools are not considered part of the proprietary educational system, perhaps because they are less occupation-oriented and their curriculums tend to be more traditionally structured.

Status of Proprietary Schools

Proprietary schools have existed as distinct institutions in the United States since the 1880's. Many were typical small businesses of the time—established by individual entrepreneurs or as family operations.[76] The overwhelming majority of these schools are still individually owned today, but corporate ownership is now the most common form of proprietary school organization.[77] Most schools are small. The average private school enrollment (includes nonprofit) in 1978 was 153, compared with an average enrollment of 556 during the same year for public postsecondary, noncorrespondence schools.[78]

According to biennial surveys of postsecondary schools that offer occupational programs, conducted by the National Center for Education Statistics (NCES), the number of proprietary schools had increased from 5,814 in 1978 to 6,141 in 1980, of which 4,151 (67.6 percent) were accredited.[79] Of the 1.5 million students enrolled in 1978 in all public and private noncorrespondence postsecondary schools, 61 percent (or 928,000 students) attended proprietary institutions.[80] An unpublished NCES survey indicated in 1980 that total postsecondary occupational enrollments had increased to 2.4 million and that the number of students attending all types of noncorrespondence proprietary schools had risen as well. (No comprehensive enrollment figure for 1980 is available at present.) Cosmetology/barber schools, business/commercial schools, flight schools, and trade schools were the largest groups of proprietary institutions operating in 1980 (see table 15). As indicated in table 16, more of these schools are accredited than any of the other types of proprietary institutions.

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[76] Donald E. Mellon, *The Role of the Entrepreneur—Educator in Private Business Education in the United States From 1850 to 1915: A Study in Conditioned Entrepreneurship*, 1975 doctoral dissertation, New York University, Graduate School of Business Administration.

[77] Steven M. Jung, *Proprietary Vocational Education* (Columbus, Ohio: National Center for Research in Vocational, The Ohio State University, 1980).

[78] Evelyn R. Kay, *Enrollments and Programs in Noncollegiate Postsecondary Schools, 1978* (Washington, D.C.: National Center for Education Statistics, 1979).

There are an estimated 250 home study schools in the United States. The 70 of these that are accredited have some 1.5 million students enrolled annually.[81]

It has been suggested that vocational education began to evolve when those seeing the need for additional and expanded occupational training attempted to join two separate educational systems—craftsmen education, which prior to that time had been in the hands of the craftsmen themselves, and academic education, which had developed around the concept of scholarship. Attempts by educationally innovative individuals to place the preparation of craftsmen in the same context as academic education met resistance from more traditional educators. However, the need for occupational education remained.

Vocational education developed as a separate branch of what was then the traditional education system, but traditional academic school standards—such as length of programs and methodology—were superimposed on this new type of educational experience. This resulted in a vocational program that was too abstract and "... lacked the desired technical knowledge and practical skill."[82]

While public and nonprofit vocational education programs continued to develop over the years, the need to which proprietary education had become at least a partial response began to take shape. A study of pesonality characteristics of 19th to early 20th century private business school founders indicates that those

Table 15.—Number of Postsecondary Schools With Occupational Programs, By Control and By Type of School: Aggregate United States, 1980 (universe data)

Type of school	Total schools	Public	Private Proprietary	Private Independent nonprofit
Vocational/technical	689	591	85	13
Technical institute	107	2	96	9
Business/commercial	1,388	3	1,348	37
Cosmetology/barber	2,128	3	2,125	0
Flight school	928	1	926	1
Trade school	773	8	739	26
Arts/design	250	0	233	17
Hospital school	859	171	51	637
Allied health	384	117	220	47
Junior/community college	1,116	905	86	125
College/university	647	260	11	376
Other	224	0	221	3
Total	9,493	2,061	6,141	1,291

SOURCE: "Statistics of Postsecondary Schools With Occupational Programs," *National Center for Education Statistics Early Release*, September 1981.

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[79] "Statistics of Postsecondary Schools With Occupational Programs," *National Center for Education Statistics Early Release*, September 1981.

[80] Kay, op. cit.

[81] Interview with Michael P. Lambert, Assistant Director, National Home Study Council, fall/winter 1981.

[82] Melain L. Barlow, "Our Important Past," in *The Future of Vocational Education*, Swanson, Gordon I. (ed.) (Arlington, Va: American Vocational Association, 1981).

Table 16.—Number of Postsecondary Schools With Occupational Programs, By Control and By Type of School: Aggregate United States, 1980 (accredited schools only[a])

			Private	
Type of school	Total schools	Public	Proprietary	Independent nonprofit
Vocational/technical	661	591	64	6
Technical institute	92	2	83	7
Business/commercial	743	3	731	9
Cosmetology/barber	1,713	3	1,710	0
Flight school	714	1	712	1
Trade school	420	8	398	14
Arts/design	146	0	136	10
Hospital school	809	171	39	599
Allied health	301	117	161	23
Junior/community college	1,112	905	84	123
College/university	647	260	11	376
Other	25	0	22	3
Total	7,383	2,061	4,151	1,171

[a] Includes all schools accredited by a nationally recognized accrediting association, whether institutional or specialized, or eligible for participation in certain Federal programs.

SOURCE: "Statistics of Postsecondary Schools With Occupational Programs," *National Center for Education Statistics Early Release*, September 1981.

who were successful in their ventures possessed both educational expertise and business know-how. More often than not, in the early years, ability as an educator was subordinate to that of entrepreneur.

At the end of this period, however, the entrepreneur without considerable sophistication in educational matters was unable to compete in the industry.[83] Perhaps the entrepreneurial skills of these early business educators and their counterparts in trade and technical schools enabled them to identify significant markets, while their educational skills enabled them to translate market needs into educational programs.

Some view proprietary education as filling a vacuum in occupational training that was created by the failure of continued development of apprenticeship education and the public vocational education system in the United States. In Europe, where these two types of educational experiences are thriving, no private vocational school system has evolved.[84]

Characteristics of Proprietary Schools

Perhaps the most distinctive characteristic of proprietary schools is their flexibility. Because they are operated as businesses, they are constantly monitoring the needs of their respective markets, for their survival depends on how well they meet the needs of their clients who are seeking adequate preparation for employment. The balance that must be maintained between providing suitable training and making a reasonable profit results in continuous assessment of and changes in operation and instruction.[85]

Proprietary schools are totally dependent on student tuition income. Rarely if ever are they endowed or do they provide student scholarships. As a result of the Education Amendments of 1972, their enrollees are eligible for financial assistance from such Federal programs as Basic Educational Opportunity Grants and Federally Insured Student Loans. In comparisions of the costs of private versus public vocational education programs, including Federal and State assistance to public institutions, proprietary school programs are less costly, although tuition for students enrolled in private, profit-seeking institutions is higher.[86]

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[83] Mellor, op. cit.

[84] Dorothy Kile Cann, *Proprietary Vocational Schools: An Alternative Lifestyle for the Disenchanted/Disadvantaged*, paper presented at the National Center for Research in Vocational Education's Employability Conference, Columbus. Ohio, October 1981.

[85] A. Harvey Belitsky, *Private Vocational Schools and Their Students: Limited Objectives; Unlimited Opportunities* (Cambridge, Mass.: Schenkman Publishing Co., Inc., 1969).

The course offerings of these institutions tend to be shorter than those of their publicly funded counterparts, and liberal arts requirements are usually not a part of their curricula. Because enrollments are much smaller than those in publicly funded vocational schools and their administrative structures are less complex, they can develop materials and introduce new courses more quickly in the occupational fields that are in demand in the industrial job market (e.g., data processing). More often than not proprietary schools include as course content only those principles which are directly related to and necessary for mastery of a specific occupation. A year-round schedule of day and evening classes is common.[87]

Instructors in proprietary schools tend to be selected because of their work experience and craftmanship rather than on the basis of their experience in the classroom or their academic degrees. They are not tenured employees, and are constantly evaluated in terms of their achievement of student satisfaction and graduate employability.[88] In some proprietary schools, instructors also serve as placement counselors. This is seen by some school administrators as yet another way to ensure that what is taught in the classroom is appropriate preparation for entry or reentry into the job market.[89]

Another characteristic of proprietary school education is its emphasis on the development of what might be called widely accepted work behavior in enrollees. Students are expected to attend classes or risk suspension, to complete assignments in a timely fashion, and, especially in business school programs, dress according to common business standards, since all these characteristics are seen as necessary for successful, long-term employment.[90]

Markets Served by Proprietary Schools

A 1980 study that used 1975 data suggests that, in general, proprietary school students share the following characteristics:

- A larger percentage are female and black as compared with students in community colleges;
- They are more likely to come from lower income backgrounds and be older, married, and out of high school for a longer time; and
- They are more likely than community college freshman to receive financial aid from Federal funding sources. The most frequent source is the Basic Education Opportunity Grant, which supported 4 out of 10 students. The greatest source of dollars is the Guaranteed Student Loan Programs.

Further comparisons in the study of students within the proprietary school sector reveal their diversity:

- The enrollees in independent business schools are largely women, while enrollees in trade and technical schools are considerably older and are comprised of a high proportion of veterans, married students, and minorities.
- More trade and technical school students come from wealthier families than do those in business schools.
- Independent business school students are more likely to participate in college work study programs, and trade and technical school students are more likely to support their studies through GI benefits and money earned from full-time work.[91]

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[86] Jung, op. cit.

[87] Belitsky, op. cit.

[88] Cann, op. cit.

[89] Interview with Stephen Friedheim, President, Association of Independent Colleges and Schools, fall/winter 1981.

[90] Ibid.

[91] Marci L. Cox, *Characteristics of Students Attending Proprietary Schools and Factors Influencing Their Institutional Choice*, 1980 doctoral dissertation, University of California, Los Angeles.

A study of proprietary schools and colleges conducted in 1975 found that students who attend proprietary schools are, for the most part, ignored by institutions of higher education. Proprietary schools do not compete for students with colleges and universities, but instead meet a specific market need. Their greatest potential impact on higher education is in diverting Federal assistance from collegiate institutions.[92]

In the 1978 survey of postsecondary schools with occupational programs conducted by NCES, 32 percent of men and 38 percent of women attended private schools (includes nonprofit). The survey results show that, during the period 1974 to 1978, more women than men were enrolled in private (includes nonprofit) schools. As illustrated in table 17, female enrollments fluctuated from 52.9 percent to 54.2 percent. Enrollments for males in private schools increased significantly from 61 percent to 67 percent during the same 4-year period. Increases in enrollment levels in private schools from 1974 through 1978 accounted for most of the enrollment growth in postsecondary occupational education.

While individual enrollees represent the primary target audience for all types of proprietary education programs, business and industry, as well as State and local education agencies, have been looked on by some segments of the profit-seeking educational system as important markets. Prior to and during World War II, for example, extensive amounts of training for industry were carried out by trade, technical, correspondence, and home study schools. After the war, however, there was a dramatic drop in the volume of contract training, as companies who had not already done so began to establish their own in-house training capabilities.[93]

Table 17.—Percent Distribution of Men and Women by Control of School

Control	Total	Men	Women
Public	100.0	58.5	41.5
Private	100.0	47.1	52.9
Total, 1974	100.0	51.0	49.0
Public	100.0	54.7	45.3
Private	100.0	45.8	54.2
Total, 1976	100.0	48.8	51.2
Public	100.0	53.1	46.9
Private	100.0	45.8	54.2
Total, 1978	100.0	48.0	52.0

SOURCE: Evelyn R. Kay, *Enrollments and Programs in Noncollegiate Postsecondary Schools, 1978* (Washington, D.C.: National Center for Education Statistics), p. 5.

Although relations between proprietary school educators and nonprofit educators have been and continue to be strained due to their different views about the profit motive in education, State education agencies and local school districts are beginning to approach profit-seeking institutions to operate special programs. The Vocational Education Act of 1963 cleared the way for public agencies to establish contractual relationships with proprietary schools where such schools can ". . . make a significant contribution to attaining the objectives of the State plan for vocational education and provide substantially equivalent training at a lower cost; or provide equipment or services not available in public institutions."[94]

Despite this enabling legislation, contracting between public and proprietary institutions remains at fairly low levels. In 1977, contracting between local school districts and private vocational schools made up between 0.6 and 1 percent of Federal outlays for vocational education under Part B of the Vocational Education Act. Barriers identified to more extensive utilization of proprietary schools included a distrust of the profit motive, a concern over highly publicized abuses of Federal student loan programs by some profit-seeking institutions, and the absence of administrative systems that would encourage more working agreements.[95]

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[92] J. Michael Ervin, *The Proprietary School: Assessing Its Impact on the Collegiate Sector* (Ann Arbor, Mich.: University of Michigan, Center for the Study of Higher Education, February 1975).

[93] Interview with William A. Goddard, Executive Director, National Association of Trade and Technical Schools; Interview with Michael P. Lambert, fall/winter 1981.

[94] Educational Testing Service, Education Policy Research Institute, *Private Schools and Public Policy* (Washington, D.C.: Office of Education, September 1978).

[95] Ibid.

Applications of Information Technology in Proprietary Education

All proprietary education industry leaders and school administrators interviewed in this investigation expressed awareness of the increasing role of information technology. However, differences of opinion exist as to how useful such technology is in specific types of proprietary institutions. It is interesting to note the applications of information technology within a group of institutions forced to be wary of high administrative costs, and known for their ability to be flexible and responsive to frequently changing needs in their respective markets.

Trade and Technical Schools

Little or no use of any form of information technology is being made by accredited trade and technical institutions. This type of proprietary school tends to be highly instructor-oriented, to emphasize learning by doing, and to restrict the amounts of theory presented in the classroom to that which is directly job-related. Video tapes are sometimes used to demonstrate equipment operation and to provide individuals with performance feedback. Costs associated with the use of educational technology are cited as a reason for its limited use. Data processing schools are the only possible exceptions.

Licensed Occupational Schools

To date, schools of cosmetology and barber colleges have made very little use of information technology in their occupational programs. The most commonly utilized forms of technology in the cosmetology field tend to be video tape, used to record remarks of visiting instructors or to demonstrate particular processes and/or techniques, and audio cassettes, used to record instructor presentations. Although the potential for the use of educational technology is recognized, the relatively small size of most licensed occupational schools and the investment required for equipment and software result in few applications.[96]

Proprietary Business Schools

Video tape, closed-circuit television, computer-managed instruction (CMI), and computer-assisted instruction (CAI) are all in use at present in profit-seeking business schools. Video tape is by far the most common form of technology being applied, closely followed by CMI, which is used for tracking applications, enrollments, financial aid, grading, and placement.[97] At Johnson and Wales College in Providence, R.I., closed-circuit television is used to link two classrooms and to provide better viewing of cooking demonstrations for students attending the culinary arts program.

An electronics school affiliated with Johnson and Wales also makes use of closed-circuit television in selected classroom sessions. Although cost remains a major deterrent to further use of these and other technologies, the administrator of this school feels that proprietary business schools will be forced to make greater applications of technology in the classroom, given what he calls the "video orientation" of today's students.[98]

Coleman College, located in LaMesa, Calif. and founded in 1973, offers programs in data processing and computer electronics to a student body of 800. Closed-circuit television is utilized in every course offered. The college has two large viewing rooms as well as individual viewing stations for student use, and its own video tape studio. Video tape is used to record lectures prior to delivery, and then to highlight them with graphics. Coleman has a CMI system used to monitor student progress, to select appropriate readings, and to administer testing.[99]

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[96] Interview with Gerald Donaway, Executive Director, National Association of Trade and Technical Schools, fall/winter 1981.

[97] Interview with Stephen Friedheim; also interview with Jack Yena, Executive Vice President, Johnson and Wales College, fall/winter 1981.

[98] Ibid.

[99] Interview with Coleman Furr, Chairman of the Board, Coleman College, fall/winter 1981.

Home Study Schools

At present, the home study industry remains very print-oriented. The National Radio Institute (NRI), a wholly owned subsidiary of McGraw-Hill, Inc., and the largest technical correspondence school in the country, with an average annual enrollment of 60,000, uses a CMI system that permits student examinations to be graded, annotated with personalized comments and mailed back to the enrollee within a 24-hour period. The admissions and financial records of NRI have just recently been converted to a computer format. Lesson-grading records will be automated in the next phase.

As part of a video cassette repair course now offered by the school, two instructional video tapes have been developed that soon will be distributed to enrollees. Plans for 1982 call for the addition of CAI to the microcomputer technology course, which begins by taking the student through basic electronics and ends with microtechnology. A TRS-80 computer, included in the cost of the course, is shipped to each student after successful completion of a certain number of lessons on basic electronics. Enrollees learn how to repair the computer and how to develop and run simple software programs. Through CAI units, to be added next year, students will learn how to do elementary programing in BASIC. Cost is a major deterrent in conversion of additional courses to CAI, video disk, or any other form of technology.[100]

Future Uses

By far the segment of the proprietary school industry doing the most to encourage additional applications of information technology in future education programs is the home study group. A recent review of current practices in home study suggested that greater use of educational technology is one way to ensure regeneration of the industry.[101] In May 1981, the National Home Study Council (NHSC) established a forum for educators known as the Green Chair Group to predict what shape home study will take by 2000.

In addition to a series of papers produced by selected individuals, the end-product of the effort will be a predictive model, developed from a Delphi survey series administered to group members. From the first round of papers submitted to NHSC in 1981, it is clear that these educators see extensive use of information technology in "distance education"—the new name they have coined for home study—in the very near future. While they see the continued use of print media, some predict that in most homes there will be interactive video and voice units with hardcopy capability that may be utilized by distance educators. Others feel that home study students will be offered a choice of straight lecture or interactive systems similar to today's PLATO. There is speculation that laser-based holography will be perfected to the point that it will be used to bring the instructor—lifesized and three-dimensional—into the home. There will also be interactive computer simulation capability.

Some see enrollment as a process that will be handled through home-based electronic devices or through home study industry-sponsored centers set up for this purpose. Industry-supported regional counseling centers will operate as nonprofit cooperatives. Counselors will be trained and compensated by distant education suppliers who are cooperative members. Satellites will be the most likely mode of transmission and will create a climate in which transnational education programs will be commonplace.

Technologies currently available, such as video tape, video disk, CAI on microcomputers, and cable will increase in use. One panel member expressed the view that in the future information technology will allow distant educational institutions to offer their students personalized instruction and services comparable to those of residence training programs, while at the same time continuing to allow them " . . . to study at their own pace and to have a full-time job while they are pursuing a program of study." One representative cautioned however, that the major problems in application will come, as they have to date, from "... enthusiasts for technology who are long on fervor and short on understanding," not from those who resist its utilization.[102]

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[100] Interview with John F. Thompson, President, National Radio Institute; also interview with Louis Frenzel, Senior Vice President, Product Development, National Radio Institute, fall/winter 1981.

[101] Louis E. Frenzel, "Ten Reasons Why Home Study May Not Survive the 80's," *NHSC News*, fall 1981, pp. 11-18.

Future Uses by Other Industry Segments

While cost will remain a prohibiting factor for the foreseeable future, other proprietary educators, especially business schools, are speculating on how existing technologies will be applied in the future in their institutions. For example, local television stations may be used to broadcast courses emanating from independent business schools.[103] One business college administrator suggested that his institution might adapt its culinary arts program for delivery to the home market via television. Another business school official feels that within 3 to 5 years, video disk will become practical for acquisition, due to considerable cost reductions. He also hopes that increased availability of video teleconferencing equipment through local telephone company offices, plus cost reductions associated with its use, will make application of this technology feasible.

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[102] Green, Chair Group, *Unpublished Papers* (Washington, D.C.: National Home Study Council, 1981).

[103] Interview with Stephen Friedheim.

Education in the Home

The family household has always been a center of learning, and its members have always played a key role in providing educational services. Grounded in the social and economic order, the family household mediates the culture, helping to provide the behavioral and cognitive skills members need to perform effectively in society.

Learning within a household is a loose and informal process. Family members act as both teachers and learners. By interacting with one another, they adopt roles, acquire personality traits, form values, and pattern their behavior.[104] Of all of the institutions that educate, the family is the most versatile and the least restricted with respect to the educational methods and the technologies it can use. Given this versatility, the household may provide a particularly suitable environment for using the new information technologies. If widely used for educational purposes in the home, the new information technologies could make the household an increasingly important center of learning.

Status of Education in the Home

Although most people receive most of their formal education in institutions outside their homes, the home has always played an important role in education, particularly in the education of the young. For even though family members are not primarily responsible for the instruction of cognitive skills, their behavior in the home strongly affects attitudes about learning. Recent studies have shown that the home environment is the most significant single factor that determines academic achievement.[105]

Adults also learn in the home, either indirectly through interaction with others or through deliberate efforts to acquire certain kinds of knowledge and skills. Books, magazines, radio, and television can all be used at home as learning resources. Some adults may continue to receive formal education in their homes through correspondence courses.[106] *

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[104] James Garbarino, "The Family: A School for Living," *National Elementary School Principal*, vol. 55, May 1976.

[105] James S. Coleman, *Equality of Educational Opportunity*, Arno Press, 1979.

[106] Dede, op. cit.

*The National Home Study Council estimates that there are 4 million correspondence students in the United States. Because

Today the American family is undergoing some radical changes that could significantly affect its ability to provide educational services in the home. At present, for example, about 40 percent of all American families are structured or operating in a way that markedly varies from the traditional norm. Since 1960, there has been, for example, a 100-percent increase in the number of single-parent families, and, since 1970, a 33-percent increase in the number of households headed by women.[107] Because single parents have less time and fewer resources to spend in or on the home than do couples, these changes may seriously reduce the ability of some families to provide for the educational needs of their children. A recent study found that children from single-parent families fare less well in school, both socially and academically.[108]

The educational needs of the family are also changing. Until recently most people had by the end of their childhood developed and acquired the skills and resources they needed to operate effectively in society. Today, however, with the explosive growth in the fund of knowledge, people are becoming increasingly dependent on continuing education for both their social and their economic welfare. It has been estimated that the average American growing up today will have to be retrained four times during his working life. He will also need more education if he is to participate in making decisions about his life and environment, and if he is to make effective use of his increased leisure time.[109]

How well families of the future can meet these enhanced educational needs will depend not only on the organization of the family and on its relationship to the rest of society, but also on the kind of technologies that are available to assist them. Printing and the mass publication and circulation of books, newspapers, and periodicals, for instance, have greatly improved the possibilities for learning in the home. And the invention and widescale deployment of radio and television has also had an extraordinary impact with respect to who learns, and what is learned at home.[110]

Many new educational technologies such as cable, video disks, and the personal computer are now being made available for use in the home at more affordable costs. In 1981, there was a market for about 1 million personal computers. It is estimated that by the late 1980's as many as half the families in the United States will have them in their homes. It is predicted, moreover, that, by the end of the 1980's, the percentage of homes wired for cable will increase from the present 28 to 50 percent.[111]

Because the widespread deployment of information technologies will significantly affect how members of a family interact and use their time together in the home, it will have a significant effect on education. It is difficult to predict, however, what that impact will be.

The new information technologies could significantly improve the learning environment for children in the home. Parents often lack the time and expertise necessary to effectively supplement their children's education at home. Traditional resources such as books, television programs and recordings are essentially passive and cannot be tailored to meet individual needs. The new technologies are individually oriented and interactive. Because they can rapidly process information, they can be used, moreover, to assist parents in diag-

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education in the home is such an informal process, it is difficult to determine its extent. A number of recent surveys have concluded, however, that nearly 90 percent of all adults undertake at least one major project a year.

[107] Winifred I. Warnat, "Future Families as Household School Institutions," *Education: A Time for Decisions,* Kathleen M. Redd and Arthur M. Harkins (eds.), selections from the Second Annual Conference of the Education Section of the World Future Society, 1980.

[108] David Melendez, "A Developing Paradox: The Role of Family Education," *Clearing House,* vol. 55, No. 5, January 1982.

[109] Katherine Patricia Cross, *Adults as Learners* (San Francisco: Jossey-Bass Publishers, 1981).

[110] Clark C. Abt, "What the Future Holds for Children in the TV Computer Age: Unprecedented Promises and Intolerable Threats to Child Development," an adapted version of the keynote address to the National Council for Children and Television Symposium on Children, Families, and the New Video Computer Technologies, Princeton, N.J., Mar. 10, 1980.

[111] Clement Bezold, *Home Computers and Telecommunications in the Future Environment of Children, a Preliminary Report,* May 1980, for the Foundation for Child Development by the Institute for Alternative Futures.

A family leaves a store in Yonkers, N.Y., with a computer and software to be used by an oceanographer father and his high-school-age children

nosing learning problems and in developing creative approaches to remedy them.[112]

If they enhance the household resources available for instruction, the technologies will make it easier for the growing number of parents who, dissatisfied with formal educational institutions, would prefer to educate their children at home.[113]* The technologies may make it easier for parents to meet the educational standards required by many State compulsory education laws.

While the new technologies may serve to enhance the possibilities for learning in all households, they could be of special educational value to those individuals who have traditionally found it difficult to learn in formal educational settings or institutions. Many adults, for example, have often been inhibited from participating in traditional educational programs because they felt too self-conscious or because such programs were too expensive, time-consuming, or inconvenient. Educational services delivered directly to the home could overcome such barriers. In addition, children living at home with a single parent who works, and handicapped individuals, confined more than usual to the home, may also find that the new information technologies have, for them, a special educational potential.[114]

On the other hand, it is possible that the technologies may actually diminish the opportunities for home education. Like television, they may be more of a technological than a cultural success. Instead of increasing individuals' access to information, and providing new ways of problem-solving, they may, in fact, lead to an unproductive use of time, provide children access to pornography and violence, and replace formal learning activities with much less valuable ones.[115] Moreover, if the technologies are primarily designed for and made available to middle-class families, they could increase rather than diminish the gap between the educationally advantaged and disadvantaged.

Libraries

As institutions that acquire, store, manage, and disseminate information, libraries provide a variety of educational services. The learning environment in a library is unstructured. Individuals of all ages are free to come and go as they please; to learn on their own, and at their own pace. Information is presented in general terms so as to be most relevant to a broad, undifferentiated clientele. The traditional medium by which learning takes place is the printed word.

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[112] Victor Walling, Thomas C. Thomas, and Meredith A. Larson, *Educational Implications of In-Home Electronic Technology*. SRI prepared for the Department of Health, Education, and Welfare, Washington D.C., May 31, 1979.

[113] Leah Beth Ward, "What Happens When Parents Turn Teachers," *The New York Times Winter Survey of Education*, sec. 13, Sunday, Jan. 10, 1980.

*The number of parents who choose to educate their children at home is difficult to estimate, since many parents do it clandestinely so as to avoid court battles. According to the National Association for the Legal Support for alternative schools, the number of families, now about 1 million, is rapidly growing.

[114] Walling, op. cit.

[115] Abt, op. cit; and J. Weizenbaum, "Once More—A Computer Revolution," *Bulletin of the Atomic Scientists*, vol. 34, September 1978, pp. 12-19.

Today, libraries are at a turning point. They must make some major decisions about whether and how they should employ the new technologies—decisions that will significantly affect their ability to perform what has been their traditional educational role. Taking advantage of these technologies, libraries might increase and/or enhance the educational activities that they provide. On the other hand, libraries might use these technologies as the means of shifting their role from one of providing public services such as education to one of providing information on a fee-paying basis.

Education in the Library

In the United States, libraries have always been regarded as popular, educational institutions. Like the public schools, they derived their support from the public education and reform movements that developed after the Civil War.[116] Traveling libraries were founded to bring news and reading materials to rural areas where book deposit stations were set up in grange halls, neighborhood stores, fire stations, and women's clubs. In the cities, libraries were established not only to provide access to books but also—like the settlement houses —to provide a haven and adult education programs for a growing number of working-class immigrants. These libraries developed rapidly during the post-Civil War period, and even continued to thrive in the depression years.[117]

More recently, libraries have tried to provide programs, materials, and services that could help all individuals, whether they could read or not, to attain their educational goals. The National Commission on Libraries and Information Sciences, for example, recently adopted the goal of:[118]

> . . . providing every individual in the United States with equal opportunity of access to that part of the total information resources which will satisfy the individual's working, cultural, and leisure time needs and interest, regardless of the individual's location, or social or physical level of achievement.

The important educational role that libraries perform has been recognized and supported by the Federal Government. Federal aid to libraries was first granted, in fact, as part of the Federal Government's efforts to enhance and equalize educational opportunities.

Status of Libraries

There are in the the United States today 29,446 individual libraries, some publicly and some privately supported. These include 14,390 public libraries or library branches, 4,676 adademic libraries, 489 military libraries, 1,451 civilian government libraries, 5,294 special libraries, 429 law libraries, 1,705 medical libraries, and 1,012 religious libraries. In addition, there are library media centers in 85 percent of the public schools.[119]

Not all of these institutions provide educational services. Unlike public libraries, special libraries, for example, are supported and maintained to provide a specific kind of information to a particular clientele. They are not necessarily open to the public.

Although libraries were once a major center of activity in many communities, they have become increasingly irrelevant to many Americans. Television and the inexpensive paperback book have replaced the library as a major source of information and entertainment. Now only about two-thirds of the population of a typical community use the public library. Another third have never used it at all.[120]

Lacking public support, many libraries operate under severe economic constraints. Most negatively affected are those that provide educational services—public libraries, school libraries, and universities. Public libraries, for example, are dependent for their financing and support on local communities that are themselves experiencing severe economic difficulties. Approximately 81 percent of their financing comes from local property taxes, funds for which many social services compete. Of these funds, public libraries typically receive less than 1 percent. Unable to meet increased costs with declining budgets, many libraries have had to cut back their services, buy fewer materials, shorten hours and share resources.[121]

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[116] V. H. Mathews, *Libraries for Today and Tomorrow* (Garden City, N.Y.: Doubleday & Co., 1976).

[117] Ibid.

[118] Ibid.

[119] *The Bowker Annual of Library and Book Trade Information*, 25th ed., 1980.

[120] Mathews, op. cit.

Also vulnerable are academic libraries—some of which have, over the last decade, had to reduce their expenditures for materials by 20 to 40 percent.[122] To meet the rising costs of operations, the Firestone Library at Princeton University is now considering charging fees for all nonaffiliated users.[123]

The major research and special libraries have had fewer of these problems. Because they have a more clearly defined and economically valued role in their institutional environments, they are more financially secure.

The growing demand for information and the development of information technologies offer libraries an opportunity to establish a new rationale for their existence and a new basis of economic support. Demographic changes, new lifestyles, and changing values may create new library users with greater and different information needs, and the new information technologies may provide possible ways of meeting them.[124]

Taking advantage of these developments, some libraries are already moving ahead to define a new role for themselves as information brokers.[125]* If they are to move in this direction, many libraries may, however, have to reconsider their traditional policy of providing free services to the public. To compete effectively with the growing number of other information enterprises, they will have to restructure their operations to meet the specific needs of their paying clientele. Unless libraries receive increased public support or subsidies from their private operations, fewer human and economic resources will be available to provide educational services to the public.

Not all libraries will use the new technologies to compete in the information market. Some libraries are trying to regain a base of popular support by using the new technologies to enhance the public services that they perform.[126] In the Plattsburg public library in upstate New York, for example, a microcomputer has been used successfully to develop

At the Trediffrin Public Library, Trediffrin, Pa., the public pays for access to the computer

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[121] Ibid.

[122] Ibid.

[123] *Princeton Alumni Weekley*, Apr. 19, 1982.

[124] Leigh Estabrook (ed.), *Libraries in Post Industrial Society* (Oryx Press, 1977); *Into the Information Age: A Perspective for Federal Action on Information* (Chicago: American Library Association, 1978); Robert Taylor, "Professional Education and the Information Environment," *Library Journal*, Sept. 15, 1979, pp. 1871-1875.

[125] Estabrook, op. cit.; Taylor, op. cit.

*Electronic technologies are already beginning to reshape the traditional library as software becomes commercially available for carrying out overall library operations.

[126] *Into the Information Age*, op. cit.

*Competing with libraries in the information market are a growing number of profit-making institutions that, taking advantage of the new information technologies, provide a broad range of information services for a fee. Describing themselves as information brokers or as information specialists, they provide such services as supplying bibliographies and documents, and, in some cases, conducting substantial research. Large organizations bill their clients at about $100 per hour; the smaller ones at about $25 to $35 per hour. The business of providing information is a thriving one, and one that is predicted to double in volume over the next 10 years.

computer literacy among rural children.*[127] If public libraries are to expand their educational programs in this way, they may need some additional support. Given the recent poor support for libraries, the economic situation in many communities, and the limited awareness of the potential use and value of the new technologies, libraries may find it impossible to raise the initial capital needed to undertake new programs of this sort.

Whether because they lack funds or because they lack initiative, some libraries will not utilize the new technologies at all. Using in-house information and traditional means of delivery, they will continue to provide free educational, recreational, and cultural services in local library buildings to those citizens who value them. If libraries follow this path, however, they may become less and less relevant to a public that increasingly values information and is computer-literate. As on-line information takes the place of books, these libraries will have less that is of interest to the public. It is conceivable, moreover, that as the proprietors of nonprint media are paid fees for the use of their materials, the authors of books housed in public libraries may seek greater compensation for the use of theirs.*[128] With diminshed public support and a shrinking clientele, these libraries may be unable to generate the economic resources necessary to maintain even their traditional services.

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*The new technologies will, moreover, allow libraries to serve better as centers of information. The Los Angeles County Public Library, for instance, now uses cable to provide information services in over 100 libraries to the 2.6 million residents of Los Angeles County. These services are designed for both the traditional library user and the nonuser, including the nonreader. As part of this program, librarians continually learn how to assess the informational, cultural, and recreational needs of their communities, and the best methods for handling, retrieving, storing, and disseminating information (Los Angeles County Public Library Draft Cable TV Policy Statement).

[127] Anne F. Romans and Stanley A. Ransom, "An Apple a Day: Microcomputers in the Public Library," *American Libraries*, December 1980.

*This program has been quite successful in meeting its goal. Attracted to the computer, more and more children are becoming regular library visitors. Adults use the computer on off-hours to try out their own programs or to develop software for business use.

[128] B. Benderly, "Libraries Do Exploit Authors," Letters to the Editor, *The Washington Post*, June 26, 1982, p. 15.

Museums

The museum is an institution that houses a collection of objects of cultural and scientific significance. The museum documents, orders, and preserves these objects for others to examine. It often helps to interpret and to explain them and to provide a context in which they may be best understood and enjoyed.

Museums in their current form are only about 200 years old. They were established for a variety of purposes: members of royal and aristocratic families built them to house their treasures; religious orders established them to enhance their places of worship; governments used them to cultivate national sentiments; scholars and artists established them to foster research and to publicize their achievements; manufacturers and industrialists used them to publicly display their wares; and wealthy individuals built museums as memorials to themselves.*[129]

Museum Education

Although education has never been their primary function, all museums possess valuable educational resources. The objects from museum collections can be used not only as self-contained exhibits, but also as illustrations for courses, lectures, and other educational purposes. Designed to be relevant to a diverse lay public, museum education is relatively unstructured. Visitors can come and go at will, drawing whatever they please from the experience. The exhibits they view are not always ordered in a typical pedagogical fashion; that is, sequentially and according to a lesson plan. More often, their arrangement is designed to enhance a particular display.[130]

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*English authors are compensated, for example, in accordance with how often their books are borrowed from public libraries. Since the money to pay the authors comes from the government, the books are freely available to the public.

[129] United Nations Educational, Scientific and Cultural Organization, the Organization of Museums, Paris, 1960.

Museum education is also more active than the passive education that takes place in a classroom. It facilitates individual participation, interaction, and response.[131] Museum visitors are, for example, often encouraged to interact with museum guides, to make drawings of art objects, to feel the texture of materials, and to pull the levers on machines.[132] In its varied purposes, its lack of educational structure, and its openness to the public, the museum is similar to the library. In fact, together they have been described as constituting the two halves of the public's memory. But museum education, while similar in purpose, is different in method. It is more sensory, using experience itself as a pedagogical tool. In comparing the two it has been said, for example, that whereas the museum represents the right half of the educational hemisphere, the library represents the left.[133]

In the United States, museums have always been conceived of as having an important educational function. Education was considered to be so important, in fact, that in some museums educational programs were set up even before buildings were built or before collections were assembled. Many museums were expected to provide vocational training together with more general educational services.[134] The Cleveland Museum, for example, was required by its charter to maintain an industrial training school.[135] Several other museums began conducting vocational counseling and training during the depression years. Today, American museums have substantially increased their educational offerings to the public.

Status of Museums*

There are approximately 1,821 museums in the United States. Of these, 62 percent are organized around a historical theme, 34 percent around an art theme, and 34 percent around a science theme. A large majority offer some educational programs. The most common programs involve school children and are jointly sponsored by museums and State and local educational departments.[136] Programs directed at elementary and secondary schools often entail museum visits designed to acquaint children with a museum's resources. Some museums also provide classes for individual students at this age level. For junior and senior high school students, there are classes in special subject areas. Museum programs for university students and postgraduates are least well developed.[137]

Museums also provide educational services aimed at other members of the community. These programs include adult educational programs and some special programs designed to meet the unique educational needs of particular groups such as the economically disadvantaged or the blind.

The ability of museums to provide educational services is circumscribed by the limited resources available to them. Most museums are small, operating with budgets of less than $50,000. Only 10 percent have operating budgets of $1 million or more. Museum resources are, moreover, relatively insecure. For example, two thirds of all museums in the United States rely on private sources for financial support, and more than half provide admissions free. Museums must also rely heavily on volunteers, who outnumber the full-time and part-time professionals working in museums.[138]

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[130] *Museums and Education*, Eric Larrabee (ed.) (Washington, D.C.: Smithsonian Institution Press, 1968).

[131] Ibid.

[132] Barbara Newson, "The Museum as Educator and the Education of Teachers," *Teachers College Record*, February 1978, vol. 79, No. 3.

[133] Ibid.

[134] Ibid.

[135] Barbara Newson and Adele Silver (eds.), *The Art Museum as Educator* (Berkeley, Calif.: The Council on Museums and Education in the Visual Arts, University of California Press).

*As defined by the National Council for the Endowment for the Arts in their study, MUSEUMS USA 1974.

[136] Ibid.

[137] *Museums USA*, National Endowment for the Arts, Washington, D.C., 1974.

Because much of their distinction and appeal derives from their ability to communicate in a sensory, unstructured fashion, museums may be particularly vulnerable to competition from the new information technologies that will have a similar appeal. On the other hand, by their very nature, they may be particularly well-suited to acquaint the public with these technologies. Some musums are, in fact, already offering the public first hand experience with microcomputers and video disks. The extent to which museums will be able to continue to provide this service will depend not only on the amount of resources that they have at their disposal. It will also depend on the readiness of both museum leaders and the public to view museums as relevant and dynamic institutions.

In the Capitol Children's Museum, Washington, D.C., children are provided with their first contact with the computer. They take their first steps tentatively but soon find that the computer itself is an interactive teacher, rewarding them immediately for the right moves

Business and Labor[139]

Advanced training and education are assuming special roles in the lives of Americans employed in all sectors of the economy, but especially among those who work in business and industry. Continuing breakthroughs in technology and their subsequent applications in the workplace change the working lives of professional employees, skilled craftspeople, semi-skilled workers, and office support personnel. Such change may take the form of slightly modified practices and procedures or even of entirely new job functions for which individuals must be retrained. This process now occurs as often in older industries such as steel, rubber, and auto, as it does in the newer high-technology firms, even if the degree of change and the reasons for it differ significantly.

Both groups are faced with the need to constantly reexamine methods and processes in order to improve efficiency and remain competitive in the marketplace. This reevaluation is especially necessary when the markets are international in scope and when competition must take into account many variables such as wage levels, government subsidies to business and export levels. The day is fast approaching when career-related training and education at all occupational levels will be a lifelong process and possibly a mandatory one.

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[138] Ibid.

[139] Beth A. Brown, *Characteristics of Industry-Based and Labor-Based Training and Education Programs, Including Uses of Information Technology in Such Programs: An Overview* (Washington, D.C.: OTA, 1981); and Beth A. Brown, *Characteristics of Industry-Based Training and Education Programs, Including Uses of Information Technology: Selected Case Studies* (Washington, D.C.: OTA, 1981).

Role of Education in the Workplace

Even in periods when there are no major changes, work force expansion and employee turnover require that training and education programs be provided by companies for new personnel. In addition, current staff must be provided with opportunities to upgrade their skills and to acquire new ones if they are to be effective in the jobs or to prepare themselves for advancement opportunities. Companies sometimes also provide special programs for employees wishing to make major career changes. Whatever events or policies make it necessary, more and more corporate resources are being earmarked for instructional activities.

The delivery of educational services to employees in business and industry is accomplished in a number of ways. A large portion of it is provided through established public and private, nonprofit and for-profit educational institutions, either by contract or in the form of cooperatively designed and administered programs. But an equally large portion is being sponsored, designed, and operated by companies themselves. Labor unions and labor organizations also are heavily involved in work-related training and education, both as cosponsors and as initiators.

Some say that the movement of industry and labor into the educational arena reflects their dissatisfaction with existing educational structures and is a comment on educators' lack of responsiveness to the needs of individuals for some degree of work preparation prior to employment. Others feel that traditional educational institutions cannot be expected to keep up with rapid changes in equipment and procedures. Still others argue that the sheer size of the task of necessary training, retraining, and professional development has demanded that industry and labor become more deeply involved, and that a little healthy competition among a broader base of alternative education providers can do nothing but improve the quality of education overall. However one views the situation, all the signs point to increased involvement of industry and labor in training and education.

Industry-Based Training and Education

Growth in industry-based training and education has been particularly pronounced since the end of World War II, although most larger firms have been engaged in some forms of instruction since their founding. While no one actually knows how many employees participate in instructional programs each year, some measures of the degree and scope of activities are available. The American Society for Training and Development (ASTD) estimates that corporations spend $30 billion annually for programs, staff, and materials. ASTD has also calculated that in the United States there are at least 75,000 individuals engaged full-time in-house training and development activities, plus another 75,000 who are employed on a part-time basis. Approximately two-thirds of ASTD's 40,000 members are employed in the private sector, either as training consultants, as staff members within corporate training departments, or as managers, directors, or vice presidents of those departments.

A Conference Board survey of industry education conducted in 1974 indicated that 75 percent of the 610 companies responding provided some in-house courses for employees; 89 percent had tuition refund programs; and 74 percent authorized and paid for selected employees, usually managers and other professionals, to take outside courses during working hours. The Conference Board estimates, moreover, that, among the 32 million individuals employed by companies that responded to the survey and that had staffs of 500 employees or more, about 3.7 million—or

11 percent—took part in in-house courses sponsored by their firms during working hours, and approximately 700,000, or another 2 percent, participated in company courses delivered during nonworking hours. Exempt employees were more frequent enrollees than those in the nonexempt category. Only those firms that had 1,000 employees or fewer appeared to place greater reliance on hiring pretrained personnel or to utilize on-the-job training.[140]

Broad estimates of worker participation are probably lower than the estimates that might be found today, especially given the present trend within U.S. factories towards installing computer-assisted design and computer assisted manufacturing systems (CAD/CAM), and the retraining requirements that accompany their use. In a study comparing the effects of technological change on the need for human resources in the chemical and allied products industries in the United Kingdom, Japan, and the United States, it was predicted that major U.S. companies, in order to meet their need for retrained production workers, would be compelled within the next 5 years to set up special training schools to provide "craftsmen" level instruction to their process operators.[141]

In addition to these changes, one can also expect that the increased use of robots and other forms of computer-assisted production may result in widespread restructuring of established occupational groups. This may, in turn, create a need for more job-related instructional programs.

Today's corporate training programs cover almost all aspects of company operations, not just manufacturing. Typically, instructional offerings address the following skills and corporate program areas:

- manufacturing and technical;
- specialized skills development;
- sales and marketing;
- safety;
- data processing;
- management and executive development;
- clerical and secretarial;
- basic education (remedial programs in math and oral and written communications for hourly as well as salaried employees);
- tuition assistance (now considered by most companies to be part of the instructional program, rather than just an element of the corporate benefits package);
- trainer's training (which is offered in firms with many small or broadly scattered installations where supervisors and others must assume responsibility for administering training packages or managing some form of instructional program); and
- retraining.

Trend Toward Decentralized Instruction

The size of the work force, the numbers of persons to be trained, the existence of multiple facilities, and the complexity of instructional needs have all led to the decentralization of corporate training operations. While some firms maintain control of training design, development, and delivery functions at the corporate level, others handle some or all instructional responsibilities at the divisional or plant level. In these situations, the role of the corporate-level training group is usually one of encouraging the sharing of information among all personnel involved in the development of human resources. Industrial training activities tend to be based in the personnel, industrial relations, or engineering departments. Sometimes three or more departments share the responsibility for instructional development, focusing on one or more of the following staff groups:

- production line (unskilled and semi-skilled);
- skilled trades;
- technical (usually engineering, data processing, and R&D);

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[140] Seymour Lusterman, *Education in Industry* (New York: The Conference Board, 1977).

[141] Frank Bradbury and John Russell, *Technology Change and Its Manpower Implications: A Comparative Study of the Chemical and Allied Products Industry in the U.K., U.S., and Japan*, Chemical and Allied Products Industry Training Board, 1980.

- management;
- supervisory (first-line); and
- professional (specialists who are not technical staff and who may not supervise or manage operations).

Training: Investment v. Expense

In companies that have a staff of over 500, size does not appear to be important in determining perceptions about employee education. If training is viewed as an investment that has a long-term payoff, even firms that have experienced economic difficulties may be willing to provide adequate financial support for instructional programs. Some corporate training groups, when they have the support of top management, are able to obtain the resources necessary to expand into new instructional areas and to use the latest equipment. Management has recognized a direct correlation between training, reduced turnover, and higher productivity. In some companies, however, training personnel have small budgets. They have to prepare in-depth justifications for refunding even at current levels of expenditures, and to prepare elaborate documentation for proposals to expand instructional activities and to utilize new equipment.

Relationship With Local Educational Institutions and Industry-Sponsored Educational Institutions

One-third of the 50 companies that OTA contacted in the course of this study, have established some sort of working relationship with high schools, vocational/technical schools, and colleges and universities in order to train or educate employees.

Companies and educational institutions jointly develop and administer programs, for which the firms provide ongoing financial support and donations of equipment. One company works with 10 local vocational/technical schools and community colleges to deliver entry-level, production-line training on an as-needed basis. Another firm has established its own in-house associate degree program, with assistance from several local colleges. In yet another case, a corporation has been the major force behind the establishment of an independent, degree-granting institute that offers graduate-level instruction in software engineering to personnel of high-technology firms in the New England region, as well as to other interested individuals in the United States and abroad.

It has been suggested that such corporate-founded institutions compete with, and will thus detract from, established college and university programs. Predictions have been made, for example, that as many as 300 colleges may close their doors during the 1980's due to declining numbers of high school graduates, at a time when 300 company-sponsored institutions of higher learning will begin operations.[142] However, companies do not see themselves as being in direct competition with traditional institutions of higher education. They maintain that they have established their programs to meet needs that the traditional education community never addressed; that their needs are so specialized that they must be met in-house; and that traditional institutions do not have the capacity, either in terms of resources or in terms of scheduling flexibility, to provide for their needs.

Information Technology in Corporate Instruction

Communications technology is being applied to a limited extent in the instructional programs of both centralized and decentralized corporate training operations. However, the trend toward the decentralization of training in larger firms has increased the potential for more widespread use. First of all, while the front-end development time may be increased, the use of technology allows more standardization in instructor-dependent designs than could otherwise be achieved, especially in cases involving the direct transfer of large amounts of knowledge. Second, while the cost of development and the expenditures for equipment are greater, the low costs of reproducing the instructional package for distribution to the field offices or plants, or of the computer time necessary for field staff to access a centralized instructional system, makes the utilization of the technology an attractive option.

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[142] Henry M. Brickell and Carol B. Aclanian, "The Colleges and Business Competition," *New York Times Survey of Continuing Education,* Aug. 30, 1981.

Third, especially in the case of self-instruction packages, there is greater flexibility in the scheduling of training sessions and more opportunities for employees to participate, regardless of the nature or location of their work site. Also, travel cost for employees attending centralized instructional programs are eliminated, and greater integration of instructional programs with actual worksite operations becomes possible.

One company has developed an instructional package for production-line equipment maintenance personnel that is run on a microcomputer integrated with a video disk unit that allows for both graphics and text display. The package is used in classroom instruction sessions, but several units have been installed on the production line, where the maintenance and repair staff are assisted on an ongoing basis. Finally, in both centralized and decentralized instructional settings, technology-based training modules or programs, (particularly those that are computer-assisted) may be used to bring course participants to a desired level of competency or to determine initial competence levels for designing classroom instruction.

Factors That May Affect Instructional Use of Technology

While communications technology has achieved acceptance within industry-based instructional programs over the past few years, there are still a number of obstacles to be overcome before more widespread utilization will be achieved. Cost is most frequently cited as a major deterrent, particularly for computer-based instructional systems and newer forms of technology such as video disk, teleconferencing, and closed-circuit television.

Another problem area is that of hardware-software compatibility, especially for corporate trainers who want to purchase commercial courseware but who have in-house computer capabilities on which they want to build. Many companies have made the decision to develop their own instructional packages rather than invest in a new system of hardware on which commercially available courseware would run. The frequency with which instructional programs must be modified—as, for example, in R&D-related training—may make the use of computer-based programs and video disk impractical.

Even the type of instruction itself may preclude the use of technology. For example, computer-assisted instruction has, to date, been found to be of little value in advanced engineering and software development courses, as well as in apprenticeship skills training. This is due to the complexity of the information that must be conveyed and, in the case of apprenticeship, to the need for repeated demonstration by a knowledgeable instructor who can respond to a trainee's questions and who can demonstrate on actual equipment. Many corporate trainers still feel that classroom instruction is the best approach. Others resist the use of technology in their programs because they feel that they are often being sold technology for technology's sake, rather than as a tool to be utilized within the framework of an existing instructional system.

Computer-Based Instruction

Computer-assisted instruction (CAI) appears to be a commonly utilized technology for industrial training. A recent survey of the uses of microcomputers in the training programs of selected Fortune 500 companies revealed that, of the 56 firms responding, about 50 percent were utilizing either mainframes or microcomputers.[143] In companies contacted by

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[143] Greg Kearsley, Michael J. Hillesohn, and Robert J. Seidel, *The Use of Microcomputers for Training: Business and Industry* (Alexandria, Va.: Human Resources Research Organization, March 1981).

OTA for this study, technical personnel such as entry-level engineers, field service representatives for computerized equipment, development programers, and applications programers are frequently trained using CAI packages.

Some companies develop their own CAI software; others purchase commercial packages. The airline industry makes extensive use of this mode of instruction for ground personnel. Some particularly interesting applications may be seen in pilot training, where CAI is used in combination with video disk to replace more expensive flight simulators. The insurance industry is beginning to utilize CAI courses with selected field office staff, such as their claims representatives and premium auditors. Occupational groups most infrequently mentioned as potential trainees are administrative/secretarial personnel and production-line staff.

Computer-managed instruction (CMI), unlike CAI, is rarely found in the industrial setting, although there are cases where it is used in airline and insurance companies. Corporate training personnel may not yet appreciate the possible advantages of CMI; they may feel that functions are best handled by instructional staff; or they may view CMI as being too costly an application.

Video Disk

The most controversial form of technology for use in corporate training is video disk. Many firms have investigated its potential application, but few seem to be utilizing it at present. One automobile manufacturer has developed a video disk program to train auto dealer mechanics on how to repair the new car models. A computer hardware and software company uses video disk in training its customer service engineering staff. It has recently converted all of the instructional programs used in its 60 field centers for customer and staff education from video tape to video disk.

Most corporate training representatives who are enthusiastic about video disk mention its random access capability and its ability to expand its utility through integration with a microcomputer. However, many instructors do not believe that the differences between video disk and video tape warrant the additional investment, especially if video tape equipment has recently been purchased. Other concerns have to do with the cost of video disk equipment, the cost of producing master disks relative to the number of copies required, and the inability of revising a video disk program once it has been created. It appears that it will be several more years before many industrial training applications of video disk will be realized.

Teleconferencing

At present, teleconferencing is of limited use in industry-based training and education programs. Industry representatives feel, for the most part, that costs are still too high to make applications feasible unless the technology has been acquired for other uses, such as business meetings, and is accessible at a subsidized rate. One firm, experimenting with audio teleconferencing to link an instructor with a group of trainees assembled several hundred miles away, found that the lack of visual stimuli distracted many of the participants who, in this case, were midlevel managers.

Another company, engaged in hotel, motel, and food service operations, uses a full teleconferencing system, initially established among 70 of its facilities for convention clientele, for in-house quarterly business performance conferences. Some firms have tentative plans to experiment over the next few years with teleconferencing in field staff training.

Satellite Communications

Applications of satellite technology within corporate training and education programs are rare, but many companies with extensive national or international field office networks place it high on their lists for future use, once costs come down and they are more certain about how it can be more effectively used. The technical instruction group of one major high-technology firm is now looking into how satellite technology might be used to beam classes that originate at the corporate engineering and development installations around the world.

Another high-technology corporation, having looked into the use of satellite communications for initial and repeated instruction of marketing personnel based in various parts of the world, decided against pursuing the project because of the cost and the uncertainties involved in securing information transmitted in this way.

Implications

There is considerable potential for the more widespread application of communications technology in instructional programs within business and industry. Training requirements will increase tremendously through the year 2000 and beyond, and there are sufficient financial resources to invest in equipment and courseware. However, the presence of computers and other equipment in the plant does not necessarily guarantee that educational and instructional applications of the technology will be made. Neither the level of sophistication of the training system nor the degree of corporate support for employee education ensure that the technology will be used. Those who are employing the computer, the video disk, and other forms of technology in their instructional programs seem to have taken their own initiative to find out how these tools might be most effectively applied.

The educational technology industry has not yet developed a comprehensive sales strategy to use with the corporate market. A number of training administrators who have contacted sales representatives reportedly felt that they were being sold technology for technology's sake rather than as an instructional tool. If broader and deeper utilization of technology in corporate instruction is a future goal, present marketing strategies may have to be reviewed and altered significantly.

Union-Sponsored Training and Education

Labor unions and labor organizations have a long history of involvement in training and education. The American Federation of Labor (AFL) began to provide such services to members in 1881, the year of its founding. In 1921, the AFL was instrumental in establishing a Worker's Education Bureau, a separate body that carried out programs for its affiliate unions. By 1929, the Bureau had become the formal education arm of the AFL. In 1936, 1 year after its establishment, the Congress of Industrial Organizations (CIO) created an education department.

When these two labor groups merged in 1955 to form the AFL-CIO, the emphasis on training and education was continued. A new education department was formed, and eventually the Human Resources Development Institute (1968) and the George Meany Center of Labor Studies (1968) were created to address the expanded needs for apprenticeship recruitment and instruction and to train union members to assume leadership positions within the labor movement.

At present, the AFL-CIO has 102 affiliate unions which, together with a few independent unions, constitute the labor movement in the United States.[144]

Education Programs

The majority of the educational programs offered, sponsored, or otherwise supported by the labor movement, fall into one of three categories:

1. *College Programs:* These are usually 2- and 4-year degree programs in labor stud-

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[144] Interview with Edgar R. Czarnecki, Assistant Education Director, AFL-CIO, fall/winter 1981.

ies offered through community colleges, colleges, and universities. In some cases they are single for-credit courses jointly developed by unions and local postsecondary institutions around such subjects as collective bargaining or leadership techniques.

2. *Apprenticeship Programs:* Apprenticeship programs usually entail specialized training in a skilled trade, craft, or occupation that is provided at the worksite and in off-the-job instruction of some type. Most of these programs are operated by the unions themselves or are jointly sponsored by unions and industry. However, a fair share are now offered by community colleges under contract or via joint ventures with unions. All 17 of the building trade unions offer apprenticeship programs, as do the maritime trade unions for those engaged in shipbuilding, machining, and seafaring.

   Other unions with apprenticeship systems include those who represent molders, pattern makers, and upholsterers, to name a few. According to figures supplied by the Human Resources Development Institute, there were, at the close of 1979, 323,866 persons enrolled in apprenticeship programs. Of this number, 18.2 percent were minorities, 6.4 percent were female, and 23.7 percent were veterans. The Labor Department's Bureau of Apprenticeship and Training has set a long-range goal of having 500,000 registered apprentices by 1984.
3. *Special Programs:* The largest number of training activities available to union members are special, or noncredit, courses offered by the education departments of individual unions to representatives on various levels—from that of shop steward to local president. Collective bargaining techniques, labor law, and parliamentary procedures are popular subjects.

Tuition assistance programs provided by management under negotiated contracts with unions are not considered to be a part of the training and education programs provided by the labor movement. However, thousands of unionized workers take advantage of this benefit every year and enroll in courses, most of which are required by companies to be job-related.[145] Because of the availability of these benefits, a number of college programs have been established in union halls and other facilities near industrial plants. Classes are offered at hours that will allow workers to attend on hourly shifts.

Courses are offered year-round, and the existence of weekend classes permits participants to earn bachelor's degrees in 4 years while they continue to work full-time.[146] The first such program, Wayne State University's "Weekend Worker College" (Detroit), was developed in conjunction with the United Auto Workers. The curriculum consists of 1 year of humanities, 1 year of social sciences, 1 year of physical sciences, and a fourth year devoted to a major field. A 2-year associate degree is also offered.[147] Some 20 programs of this kind were expected to be under way by the end of 1981, and the American Federation of Teachers is now trying to establish similar projects in six other locations.[148]

Other Types of Instructional Programs

Various unions have been active in providing other training and educational services to their memberships and to the community as a whole. Unions and companies in some areas of the country have cosponsored training designed to prepare individuals for advancement from entry-level positions or what would otherwise be considered jobs with no promotional opportunities. Funding, in most cases, has been provided by the Comprehensive Employment and Training Act (CETA) title II and title III grants, although some programs have been privately funded by labor, by industry, or jointly by labor and industry.

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[145] Interview with John Carney, Education Director, United Steelworkers of America, fall/winter 1981.

[146] Interview with Jane McDonald and John Good, Human Resources Development Institute (AFL-CIO), fall/winter 1981.

[147] "Worker V: More Colleges Offer Programs for Blue Collar Employees," *Wall Street Journal*, May 12, 1981, p. 1.

[148] Interview with Edgar R. Czarnecki, fall/winter 1981.

Where other jobs are available within a reasonable geographic range, unions have also engaged in the retraining of members who have lost their jobs due to plant closings and site relocations. The "Mass Layoff Job Search Club" was formed in Midland, Pa., to provide such assistance to 300 former Crucible Steel workers whose jobs were eliminated. The program is jointly sponsored by the United Steelworkers local and Crucible Steel. In St. Louis, Mo., a joint labor-management committee has been formed through which local unions, businesses, educational institutions, and community-based organizations are working together to identify ways of dealing with the large numbers of displaced workers in the area. On the campuses of local community colleges, career readjustment and reemployment centers have been set up to handle the needs of an expected 1,000 participants.[149]

For several years, the AFL-CIO's Human Resources Development Institute has operated a nationwide apprentice outreach program for minorities and women to recruit and prepare them for available apprenticeship slots. Many AFL-CIO affiliates and independent unions conduct preapprenticeship training sessions and basic education programs for young people who wish to improve their reading, math, and other skills so that they might qualify for participation in apprenticeship programs. Career education and vocational exploration programs sponsored by local school systems and others also receive substantial support from labor unions and labor organizations.[150]

Information Technology in Union-Sponsored Instruction

There is no evidence in the literature or in the interviews conducted by OTA with labor education directors to suggest that unions are taking great advantage of information technologies. These technologies may be considered inappropriate to the apprenticeship system. The importance of the individual instructor, the duration of the apprenticeship period, lasting usually 4 years, and the unique funds of information that must be conveyed, such as local building codes which differ from area to area, tend to discourage the use of technology such as computer-assisted instruction.

In the college programs and special programs, there is also little use of information technology. One reason for their infrequent use is that the lecture method has generally been considered to be successful in labor education programs. Films, slides, and video cassettes were most often used by those who were interviewed. The United Steelworkers of America, for example, uses video tapes and cassettes in mock arbitration exercises at the union's Linden Hall Residential Training Center, but they use no other form of technology. The cost of computer-based learning systems was cited as a deterrent to their use.[151]

A national AFL-CIO training representative stated that most member unions were just beginning to use video cassettes in arbitration simulations and for circulating messages of their presidents to State and local chapters. He also described a model communications project, "To Educate the People Consortium," which was staged by Wayne University as a part of its local instructional program. To stimulate interest in using the medium as an educational device, union representatives in 100 cities across the country were connected by a network via two-way, closed-circuit television. The demonstration was so successful that another model broadcast, "Safety and Health for Women," is now being planned.[152]

A Texas State AFL-CIO representative reported that video cassettes were used in education programs, but he indicated that none of the other newer forms of technology were being used because they were inappropriate for the kinds of programs offered—mostly workshops—and because they were too costly.[153] A Dallas AFL-CIO representative could identify no applications of technology. He regards classroom training with lectures as the most popular format. However, he hopes to use cable television once it becomes available in the Dallas area as a way of more effectively reaching the membership (1985).[154] The United Rubber Workers do not use educational technology either, and they have not thought about it for the future.[155]

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[149] Interview with Jane McDonald and John Good, fall/winter 1981.

[150] Ibid.

[151] Interview with John Carney, fall/winter 1981.

[152] Interview with Edgar R. Czarnecki, fall/winter 1981.

The International Brotherhood of Electrical Workers (IBEW) employs computer systems to track apprentices in training. It has established some joint information systems with the Department of Labor's Bureau of Apprenticeship Training. In addition, an IBEW representative reported that video disks are used in labor education seminars. Unions that are using video cassettes in training packages include the United Carpenters and Joiners of America and the American Postal Workers.[156]

In contrast to industry-based instructional activities, there seems to be less potential for applications of information technology in union-sponsored training and education programs, primarily because such programs are still highly instructor-centered and classroom-oriented. However, the success of closed-circuit television experiments initiated by the labor movement suggests that this form of technology might achieve more acceptance and be utilized for national and regional educational sessions in the future. Perhaps union association with colleges and universities that utilize educational technology in labor education courses and degree programs may result in more widespread application in union-sponsored training and education activities.

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[153] Interview with Ruth Ellinger, Education Director, Texas State AFL-CIO, fall/winter 1981.

[154] Interview with Willie Chapman, AFL-CIO, Dallas, Tex., fall/winter 1981.

[155] Interview with James Peake, Education Director, United Rubber, Cork, Linoleum and Plastic Workers, fall/winter 1981.

[156] Interview with Kenneth Edwards, Director, Skill Improvement Training, International Brotherhood of Electrical Workers, fall/winter 1981.

Chapter 7

State of Research and Development in Educational Technology

Child watcher of Sesame Street: Dr. Palmer records the viewing habits of two intent preschoolers with a simple set-up including a TV set which receives pretaped material and a slide projector which exhibits fresh still photographs every few seconds

Chapter 7

State of Research and Development in Educational Technology

Support of basic research and development (R&D) in most fields of technology has traditionally been a function of the Federal Government. The Government has also funded applied research when its purpose was to advance certain national goals or to serve the mission needs of Federal agencies. R&D not only generates important new knowledge about educational technology, but, when done in academic centers, it can also provide an instructional base with which to train experts needed to create effective instructional materials.

Findings

- Gaps in our knowledge about information technology could limit our ability to use it effectively, and, if leading to its inappropriate implementation, could negatively affect both the learners and the institutions using the technology.
- The Department of Defense (DOD) now provides the bulk of R&D support in the field of learning technology.
- Civilian agency funding for R&D in learning technology, the majority of which comes from the Department of Education, has fallen precipitously from a temporary short-term peak in the late 1960's.
- If Congress wanted to stimulate effective educational applications of information technology, it would have to undertake or foster a substantial program for R&D. The Secretary of Education has stated that a program of research support is a major administrative priority, and that such a program has been built into the 1983 budget request.
- Given the number of agencies that have an existing or potential interest in R&D in this area, the Federal Government may want to coordinate these efforts so as to allow for a greater exchange of information and a more efficient and effective allocation of responsibilities. The responsibility for such coordination could be vested in a single agency, or existing interagency group, or an agency especially established for that purpose.
- In light of the tight Federal budget and the potential interest of the private sector in educational technology, mechanisms for leveraging Federal support to stimulate industry and foundation funding for R&D might be investigated.

Introduction and Background

Since the 1950's, R&D in educational technology has been funded by the Federal Government, by foundations, by the business community, and, in some cases, by all three in collaboration with one another. To date, the role of the Federal Government has been to provide initial and limited ongoing support that might serve to attract other sources of funding. The Federal agencies most deeply involved have been the National Science Foundation (NSF), the Department of Education (OE) (formerly a part of the Department of Health, Education, and Welfare), and DOD.

Acting on a legislative mandate to foster computing in science education, NSF, through its Science and Engineering Education Directorate, has funded a variety of computer-assisted learning research efforts, including the initial development of the PLATO instructional system at the University of Illinois in 1959.[1] Grants have been made to provide initial and ongoing support of educational television projects such as NOVA and 3-2-1 Contact, both of which have received worldwide acclaim and have served as models for programs in other nations. NSF has also funded efforts to determine how computer-controlled video disk may be used to enhance science education in physics and biology. It has issued grants for science news coverage broadcast on 227 public radio stations, and has sponsored early satellite experiments. In addition, in fiscal years 1980 and 1981, NSF and the National Institute of Education (NIE) jointly funded "Mathematics Education Using Information Technology," a program that, through the use of small grants, has encouraged the development of computer software for use in mathematics curricula.

Support of educational technology R&D dates back to the early 1960's with the inception of the Educational Broadcast Facilities Program, which was designed to improve the national capabilities of public radio and television. In fiscal year 1968, OE funding of the Children's Television Workshop, along with that of the Carnegie and Ford foundations, led to the creation of Sesame Street and The Electric Company, two programs that have won international recognition. Computer-based instructional materials on the elementary, secondary, and college levels for target populations such as the handicapped, video disks for classroom use, and experiments with educational broadcasts via satellite, have all been undertaken with OE support.

DOD has also made significant contributions to the R&D of educational technologies. Faced (since the 1970's) with a greater need to provide basic skills instruction to recruits, to train individuals to operate more complex equipment, and to deliver instruction in the field in multiple locations, the military has placed renewed emphasis on developing applications of technology. Through the tri-services of the Army, the Navy/Marine Corps, and the Air Force, DOD has, since then, sponsored R&D projects in the areas of:

- computer-based education;
- computerized-adaptive testing;
- simulation and gaming;
- video disk technology;
- artificial intelligence;
- instructional development/authoring aids; and
- job-oriented basic skills training.[2]

Other agencies that have made grants on a periodic basis include the National Aeronautics and Space Administration (health/education satellite projects in the 1970's), the Environmental Protection Agency, the Department of Interior, the National Institues of Health (contributions to NSF grants in science broadcasting), and the Department of Commerce (telecommunications projects jointly funded with OE).

In recent years, the Federal Government's involvement in and support for educational hardware, software, and basic research has decreased. A brief review of the current trends in R&D, and of the comparative roles that the public and private sectors have played in this area will contribute to an understanding of the causes and potential impact of declining Federal support.

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[1] The National Science Foundation Act, Public Law 81-507.

[2] B. K. Waters and J. H. Laurence, *Information Technology Transfer From Military R&D to Civilian Education and Training*, report prepared by Human Resources Research Organization for the Office of Technology Assessment, January 1982.

Changing R&D Climate

Since 1980, the industrial sector has provided more funding for all types of R&D activities than the Federal Government. Recent projections indicate that, in 1982, industrial funding will rise to $37.7 billion, which represents an 11.4-percent increase over 1981, and 48.6 percent of the total $77.6 billion available for support of R&D. Federal funding will rise to $37 billion, an increase of 13.3 percent over 1981, and 47.7 percent of the total R&D expenditure for 1982. Academic institutions are expected to contribute $1.7 billion (2.2 percent of total), while other nonprofit groups will provide $1.1 billion (1.5 percent of total). Industry will perform 70.8 percent ($55 billion) of all R&D, while the Federal Government will carry out only 13 percent ($10.1 billion—a large portion of this defense-related). Academic institutions will perform 12.5 percent of all R&D ($9.7 billion) and other nonprofit groups 3.6 percent ($2.8 billion). Thus, although once at the center of basic research and R&D efforts, colleges and universities will now receive only one-fifth of the moneys earmarked for these activities.[3]

The Economic Recovery Tax Act of 1981 may improve the universities' chances of receiving basic research grants from industry, since it allows companies to treat such grants as qualified research expenses on which 25 percent tax credits may be claimed. The act is also expected to encourage corporations to donate scientific equipment to universities for R&D use.[4] Some firms are also establishing long-term working relationships with universities for the performance of basic and applied research. These arrangements are economical to them because of lower labor costs. In addition, faced with increased international competition, firms are more interested in tapping the reserves of university research talent.[5]

Shifts in the source of funding of and in the majority of performers of R&D from the public and nonprofit sectors to the private sector have occurred after a period in which the business community (especially manufacturing industries) had sharply reduced involvement in basic research and long-term R&D projects. As reasons for these changes, business leaders cite increased Government regulation, increased rates of inflation that make return on long-term investments more questionable and an increased concern for the short-term effects of R&D on profits. As a consequence, many companies have focused their R&D efforts on short-term, low-risk, incremental projects.[6]

Industrial R&D funding has also been affected by the availability of R&D tax shelters —limited partnerships formed to finance new product development. These provide companies with virtually free money until their products can be marketed. But these shelters are used only in selected parts of the country, and then, only in newer firms willing to take greater risks.[7]

To complicate matters further, a severe shortage of scientists and engineers, projected to last through the 1990's, has had a tremendous impact on U.S. R&D efforts in all sectors. The most alarming effects are seen in the faculties of colleges and universities, where, at the start of the 1980-81 academic year, approximately 10 percent of the teaching/research engineering positions remained vacant. Only 5 percent of engineering undergraduates now choose to pursue doctorates in contrast to 11 percent in the 1970's. Those who earn higher degrees are electing to start careers in industry, where salaries are considerably higher and equipment and resources are more plentiful. In a recent NSF study of engineering schools conducted by the American Council on Education, 35 percent of the respondents reported that, because of shortages in personnel, their institutions had to cut back research efforts, increase faculty teaching loads, and curtail certain courses when demand for engineering talent, especially in high-technology industries is at an all-time high.[8]

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[3] J. J. Duga, *Probable Levels of R&D Expenditures in 1982: Forecast and Analysis* (Columbus, Ohio: Battelle Laboratories, December 1981).

[4] R. W. Wood, "Research and Development Expenditures Under the Economic Recovery Tax Act," *Taxes,* November 1981, pp. 777-783.

[5] "Industry Funding of Research at Schools Grows as Firms Find the Work a Bargain," *Wall Street Journal,* vol. 102, June 24, 1980, p. 14.

[6] E. Mansfield, "How Economists See R&D," *Harvard Business Review,* November-December 1981, pp.. 98-106.

[7] "R&D Tax Shelters Are Catching On," *Dun's Business Month,* pp. 86-87.

The shift in sources of funding and in the amount of R&D performed by industry, as well as the critical shortages of scientists and engineers, have weakened the ability of the United States to compete in worldwide R&D activities, and have hampered U.S. manufacturing firms from effectively competing in international markets.

Federal Funding

Even more critical than the state of R&D in general is the current state of R&D for educational technology. Analyses made in March 1981 of the Federal budget proposals for fiscal year 1982 indicate that education and research programs, which accounted for approximately 4 percent of all Federal spending in 1980, will constitute 13 percent of the total spending reductions. Even with the approved fiscal year 1982 funding levels established by Congress in December 1981, Federal expenditures for education and research in constant dollars will be well below actual 1980 levels. In 1982, spending will be about 20 percent below 1980 levels, and, by 1984, it may fall by as much as 53 percent below.

Federal support represents a significant portion—in some cases up to 25 percent—of funds that the nonprofit sector, including universities and other educational institutions, uses for operations and programs. Federal support grew over the past 20 years, as the Federal Government came to rely increasingly on nonprofit organizations to deliver and/or evaluate federally funded programs. While foundations and corporations have been generous with funding, their contributions will probably not make up for reduced Federal involvement, especially since nearly one out of every four of the dollars eliminated from the Federal budget for fiscal year 1982 would have gone to a nonprofit organization.[9]

Private Funding

Foundations have also played an important educational role by financing commissions and studies, funding development and demonstration projects, organizing conferences, and supporting think-tanks. Recently, the Sloan Foundation supported a conference at which educators and representatives of industry discussed how mathematicians might be retrained for careers in applied computer science in order to alleviate severe occupational shortages. The Carnegie Foundation has participated in jointly funded broadcasting projects produced by NSF. The Hewlitt Packard Foundation has expressed an interest in supporting NSF-sponsored science programs for commercial television. Plans for the project may be jeopardized, however, because of funding reductions within NSF's Office of Science and Engineering Education (formerly the Science and Engineering Education Directorate).

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[8] F. J. Atelsek and I. L. Gomberg, *Recruitment and Retention of Full-Time Engineering Faculty, Fall 1980* (Washington, D.C.: American Council on Education, October 1981).

[9] L. A. Salamon with A. J. Abramson, *The Federal Government and the Nonprofit Sector: Implications of the Reagan Budget Proposals* (Washington, D.C.: The Urban Institute, May 1981).

In the past, selected companies have been generous in their support of education. Some have participated with Federal and State governments in jointly funded computer-based learning projects as well as other technology-based activities. Although it is difficult to estimate the amount of corporate support for educational technology, education has always been a high-priority area for support. The Annual Surveys of Corporate Contributions, a series conducted by the Conference Board for the years 1978, 1979, and 1980, shows that contributions made to educational institutions and organizations for a wide variety of purposes have increased from $256.3 million to $375.8 million—from 37 percent of the total contributions of reporting companies in 1978 ($693.2 million) to 37.7 percent of those firms reporting in 1980 ($994.6 million).[10] Support of education measured as a percentage of pretax net income has increased from 0.179 in 1978 to 0.220 in 1980.[11] However, if funding for such activities is to remain at the 1980 levels (in constant dollars), private donations will have to increase substantially in all program areas, including education and research. An Urban Institute study of how the Federal budget cuts, as proposed in March 1981, would affect the educational programs of nonprofit institutions showed that they will receive $0.7 billion dollars less in income from public sources, and they will receive $7.3 billion from private sources. To maintain the existing value of private support, contributions from the private sector must increase by 17.9 percent:

> . . . private giving would have to increase by 144 percent between 1980 and 1984 in order to keep up with inflation and make up for revenue lost to nonprofit organizations as a consequence of the budget cuts. By comparison, however, during the most recent five-year period, private giving in practice increased only 38 percent. In other words, in order for private nonprofit organizations to hold their own . . . even using (administration) inflation assumptions, private giving would have to increase four times faster between 1980 and 1984 than it did over the five-year period just ended.[12]

There is evidence that corporations are willing to increase their support of educational, arts, and social service programs affected by Federal budget reductions. Corporate giving clubs are being organized by business leaders in various part of the country to ensure that companies set aside up to 5 percent of pretax revenues for this purpose. However, according to Internal Revenue Service records, only about 35 percent of the Nation's 1.5 million profit-reporting firms claimed any charitable deductions in 1977 (latest figures available), with only 58,000 taking advantage of the full 5 percent allowable deduction. Furthermore, most of these donations went to support local community projects rather than national programs. Few, if any, of these donations carry with them the requirement that projects' results be widely disseminated.[13]

Hopefully, the founding of such clubs will offset the potential negative effect that the provisions of the Economic Recovery Tax Act of 1981 might have on charitable donations. Because the act allows faster depreciation and more investment tax credits, it will have the effect of reducing taxable income.[14] A recent Conference Board survey of trends in business volunteerism in the largest U.S. manufacturing, service, financial, and transport firms indicated that, for a variety of reasons—among them current economic conditions, companies are not redirecting or expanding their program interests in response to Federal budget reductions. In fact they may not be able to give as much in the future as they have in the past.

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[10] It is important to note that response rates to the *Annual Survey of Corporate Contributions* varied for the years cited: 1978—759 companies; 1979—786 companies; 1980—732 companies. Annual tabulations of corporate contributions published by the American Association of Fund-Raising Counsel, show that giving levels for 1980 and 1981 were $2.7 billion and $3.0 billion respectively.

[11] Conference Board and the Council for Financial Aid to Education, *Advance Report From the Annual Survey of Corporate Contributions, 1980* (New York: The Conference Board, Inc., 1981).

[12] Salamon and Abramson, op. cit.

[13] "How Corporate 'Clubs' Fill the Gap in Giving," *Business Week*, Nov. 23, 1981, pp. 54F-55.

[14] "More Tax Incentives for R&D," *Business Week*, Sept. 7, 1981, pp. 74L,P.

Some respondents said that they thought that a lower corporate tax rate may well discourage giving. Representatives of 6 of the 10 companies said that they do not expect to lend more executives to nonprofit institutions in place of, or in addition to, direct contributions.[15]

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[15] E. P. McGuire and N. Weber, *Business Volunteerism: Prospects for 1982* (New York: The Conference Board, Inc., January 1982).

Federal Commitment to Educational Technology R&D, Fiscal Year 1982

Approved congressional budget levels and conversations with budget and program officers in NSF, OE, DOD, and other agencies, suggest that the Federal investment in educational technology R&D in fiscal year 1982 will amount to $273.915 million, $256 million of which will be utilized by the tri-services (Army, Navy/Marine Corps, and Air Force) as a part of the Training and Personnel Systems Technology Program (TPST). Ongoing program elements of TPST, according to which specific projects are funded, are listed in table 18; selected project topics funded within these program elements are listed by service branch in table 19.

Of the remaining $17.915 million (non-DOD funding), the largest percentage—an estimated $5.55 million—will go to support computer research, including software development in science, math, reading, and written communications. Educational television projects will receive the second highest amount—an estimated $5.236 million. The remaining $7.129 million will be used to support educational applications of video disk and teleconferencing and to develop special technology applications for educating the handicapped.

Breakdowns of R&D funding within NSF, OE, and DOD and estimates of the dollars set aside for educational technology R&D projects in fiscal year 1982 are given in tables 20, 21, and 22. NSF has provided $4.536 million—0.457 percent of the agency's total projected R&D expenditure ($991 million)—to grants of this type. Educational technology projects will be funded to varying degrees within six program areas in OE. The total projected amount is $13.379 million, 12.45 percent of the ap-

Table 18.—Department of Defense Training and Personnel Systems Technology R&D Program Elements and Funding Levels—Fiscal Year 1981-82

	Dollars in millions	
Program element	Fiscal year 1981	Fiscal year 1982
Army		
Training, personnel, and human engineering	$3.9	$4.0
Human factors in systems development	7.0	8.7
Human performance effectiveness and simulation	3.2	3.5
Manpower, personnel, and training	6.2	6.0
Nonsystem training devices technology	2.7	2.7
Synthetic flight simulators	3.9	7.8
Manpower and personnel	3.4	4.7
Nonsystem training devices development	0.0	1.4
Human factors in training and operational effectiveness	1.9	3.1
Education and training	7.8	9.6
Training and simulation	1.5	2.2
Synthetic flight training systems	0.6	8.3
Nonsystem training devices engineering	12.2	12.9
	$54.3	$74.9
Navy and Marine Corps		
Behavioral and social sciences	7.7	8.8
Human factors and simulation technology	5.9	6.5
Personnel and training technology	5.7	6.4
Human factors engineering development	2.9	3.1
Manpower control system development	3.1	2.8
Man-machine technology	0.0	0.0
Education and training	4.8	3.7
Navy technical information presentation system	1.8	1.3
Marine Corps advanced manpower training system	1.3	1.5
Training devices technology	6.0	8.0
Training devices prototype development	13.9	10.4
Prototype manpower/personnel systems	1.1	5.0
Air warfare training devices	13.7	27.9
Surface warfare training devices	34.4	41.7
Submarine warfare training devices	2.9	4.6
	$105.2	$131.7
Air Force		
Human resources	4.8	4.9
Aerospace biotechnology	8.2	8.8
Training and simulation technology	12.9	14.2
Personnel utilization technology	5.3	5.5
Advanced simulator technology	3.2	2.2
Innovations in education and training	1.7	2.5
Flight simulator development	5.5	11.3
	$41.6	$49.4
Total	$201.1	$256.0

SOURCE: Department of Defense, Office of the Undersecretary for Research and Engineering, compiled January 1982.

proved R&D funding level of $107.4 million. Of $19.9 billion approved for DOD R&D funding, 1.28 percent, or $256 million, will be spent on training and simulation devices, computer instructional software development, and other technology-based projects. Government-wide commitment levels to educational technology projects are broken down by agency in table 23.

Table 19.—Training and Personnel Systems Technology R&D Program: Selected Project Topics—Fiscal Year 1981-82

Army

Man-computer communication techniques
Application of video disk to tactical training and skill
Qualification testing
Technology-based basic skills and individual skills development systems
Computer-based maintenance training aids
Integration of microwave and computer technologies
Computer-based maintenance training aids

Navy/Marine Corps

Computer-based maintenance training and other computer-based instructional systems
Individualized automated training technique
Computer literacy (teaching computer programing skills)
Advanced training technology development
Advanced voice interactive systems development
Computer-assisted design and evaluation systems
Computerized personnel acquisition system development
Utilization of computer graphics for maintenance instruction
Computer-based basic skills instruction
Advanced computer-aided instruction for complex skills
Experimental, technology-based combat team training systems
Computerized course authoring systems
Computer-based speech recognition and synthesis

Air Force

Human-computer combinations
Computer-aided technical instruction
Advanced visual technologies
Computer-based maintenance aids

SOURCE: Department of Defense, Office of the Undersecretary for Research and Engineering.

Table 20.—National Science Foundation R&D Budget, Fiscal Year 1982 for Selected Program Areas

Program area	Approved R&D funding level	Funds for education technology R&D	Percent of program total
Mathematical and Physical Sciences ..	$273 million	0	0
Engineering and Applied Sciences	$92 million	0	0
Scientific, Technological, and International Affairs and Cross-Directorate Programs	$40 million	0	0
Science Education, Development, and Research[a]	$21 million	Estimated $2.2 million computing in education. Estimated $2.336 million science broadcasting.	21.6%
Subtotal, selected program areas....	$426 million	$4.536 million	10.6
Total (all R&D within agency)	$991 million	$4.536 million	0.457%

[a] Legislative mandate to foster computing in science education.

SOURCE: American Association for the Advancement of Science, National Science Foundation, and Office of Technology Assessment.

Table 21.—Department of Education R&D Budget, Fiscal Year 1982 for Selected Program Areas

Program area	Approved R&D funding level	Funds for education technology R&D	Percent of program total
National Institute of Education	$53.4 million	$1.3 million (est.)	2.43%
National Institute for Handicapped Research	$28.6 million	$0.2 million (est.)	6.99
Bilingual Education	$6.0 million	0	0
Handicapped Research Innovation & Development	$7.2 million	$0.9 million	12.5
Vocational Educational Programs of National Significance	$5.5 million (est.)	0	0
Educational Technology	$6.679 million	$6.679 million	100
Special Education Resources		$1.8 million	
Fund for the Improvement of Postsecondary Education	$10 million	$2.5 million	40
Total (all R&D within agency)	$107.4 million	$13.379 million	12.45%

SOURCE: Department of Education and Office of Technology Assessment.

Table 22.—Department of Defense R&D Budget, Fiscal Year 1982 for Selected Divisions

Department	Approved R&D funding level	Funds for education technology R&D	Percent of program total
Army	$3.6 billion	$74.9 million[a] (est.)	20.8%
Navy and Marine Corps	$5.9 billion	$131.7 million[a] (est.)	2.23
Air Force	$8.9 billion	$49.4 million[a] (est.)	5.55
Defense agencies	$1.7 billion	0	0
Total (all R&D within department)	$19.9 billion	$256.0 million	1.28%

[a] Additional R&D efforts may exist that are not captured within training and personnel technology program data base.

SOURCE: American Association for the Advancement of Science; Department of Defense; and Office of Technology Assessment.

Table 23.—Projected Federal Expenditures for Educational Technology R&D, Fiscal Year 1982

Department	Projected expenditure educational technology—R&D	Total R&D budget (approved levels)
National Science Foundation	$4.536 million (est.)	$991 million
Department of Education	$13.379 million (est.)	$107.4 million
Department of Defense	$256 million (est.)	$19.9 billion
Total	$273.915 million (est.)	$20.99 billion

SOURCE: Office of Technology Assessment and American Association for the Advancement of Science.

Discontinued and Consolidated Projects

Research on the educational applications of satellite technology will not be supported by the Federal Government in fiscal year 1982, with the exception of one small project sponsored by NIE and conducted by a regional educational laboratory. Support for Federal telecommunications research and demonstrati has been discontinued, except for two proje that will receive some funding for fiscal year 1982. The Deafnet Telecommunications Model, the product of a 3-year effort that involved modifying existing electronic mail technology, will be disseminated to potential users under a $300,000 grant. OE's Division of Education- Technology (Office of Educational Research and Improvement) will provide $1.1 million to support "Project Best," a series of teleconferences designed to help officials in 45 States to understand the potential of the technology. The National Telecommunications Program established by Congress in 1976 to "promote the development of nonbroadcast telecommunicatons facilities and services for education and other social services" was not reauthorized for fiscal year 1982. It would also appear that a 3-year project that was designed to demonstrate the use of teletext in the United States and that was jointly sponsored by OE, NSF, the National Telecommunications Information Administration, and the Canadian Government, will be discontinued. (In fiscal year 1981, OE contributed $1 million to the effort.) The Television and Radio Program authorized by the Emergency School Aid Act of 1972 under which grants to reduce minority isolation in the media were made, as well as the Basic Skills and Technology Program authorized by the Education Amendments of 1978, designed to encourage research into the application of technology to problems in basic skills instruction, have been consolidated with other programs into a State educational block grant at overall reduced levels of funding. (In 1981-82, the combined support for these two programs amounted to $6.5 million.) OE support for video disk development will not be pursued due to lack of funds. However, several video disk projects included within a group of multiyear contracts previously awarded by OE (an estimated $20 million investment for all such contracts) are scheduled for completion in fiscal year 1983 and fiscal year 1984.

Continuing Projects

Multiyear grants that will continue to be funded in fiscal year 1982 are listed by agency in table 24. Seven ongoing educational television projects will be supported by OE. The use and adaptation of technology for the handicapped and for special education will be encouraged. And, through the Fund for the Improvement of Postsecondary Education, grants will be made to local educational projects that use teleconferencing, computer-aided instruction, video disk, and other forms of technology (estimated $25.7 million). NSF will continue its science broadcasting program ($2.336 million) and will review its computer-based education projects and others similar to them ($2.2 million). Support has been discontinued for the Mathematics Education Using Information Technology Program, designed to encourage computer courseware development, and previously supported jointly with OE. To date, NSF has contributed $3.5 million, and NIE has contributed $0.5 million to this project. In fiscal year 1982-83, NIE will provide $0.6 million in support.

Information about which specific projects will be funded in this fiscal year under elements of DOD's Training Personnel and Systems Technology Program is still unavailable. However, some idea about the nature of these activities can be gained by looking at selected tasks that are under way at the Army Research Institute (ARI). ARI will continue development of a hand-held computer for vocabulary building, a computer-assisted career counseling system, and a special data management system that will integrate video disk technology with a computer for basic skills instruction (estimated at $2.25 million).

Table 24.—Continuation Grants for Educational Technology R&D, Fiscal Year 1982[a]

Program	Grant description	Funding level
Department of Education		
Division of Educational Technology (Office of Educational Research and Improvement	**Microcomputer Software**	$2.25 million
	Development: Elementary grades (3 yrs. funding at $150,000 per project)	
	Ohio State: mathematics; development and testing in 25 schools by fiscal year 1983.	
	Wycatt: reading; Bolt, Beranek and Newman: written communication composition	
	Video disk	
	University of Nebraska: development of Spanish-English dictionary and microcomputer software.	$0.225 million
	American Institute of Research: video disk for music and math curricula for elementary grades; 45 site demonstrations and electronic mail component.	
	Teleconferencing	$0.250 million
	"Project Best:" assistance to officials in 45 States in understanding potential of technology; electronic mailbox compenent; 8 teleconferences.	$1.1 million
	Television	
	Seven projects: (selected grants highlighted)	$16.175 million
	"3-2-1 Contact:" production funds to Children's Television Workshop ($1 million).	
	"Power House:" health and nutrition—economically disadvantaged minority youth ($3.5 million).	
	"Kids:" program for elementary grades on radio broadcasting ($1 million).	
National Institute for Handicapped Research	Adaptation of educational technology for use by handicapped	$0.2 million (est.)
Special Education Resources	Deafnet Telecommunications Project—model dissemination ($0.3 million).	$1.8 million (est.)
	Line 1 Caption Broadcasting Program ($1.5 million).	
Handicapped Research—Innovation Development	Technology Utilization Project	$0.9 million (est.)
National Institute of Education	"Mathematics Education Using Information Technology:" (until fiscal year 1982-83 jointly funded with NSF; $0.6 million). Computer courseware development "Calculator Information Center" ($0.1 million).	$1.3 million (est.)
	"Computer Software Clearinghouse" ($0.2 million). Portion of Regional Educational Laboratories budget utilized for educational technology projects: courseware development; satellite telecommunications project (est. $0.4 million).	
Fund for the Improvement of Postsecondary Education	Educational television, teleconferencing, computer-aided instruction, and video disk (local projects)	$1.5 million (est.)
National Science Foundation		
Office of Science and Engineering Education	Computer-based education, CAD/CAM[b] education, and other projects currently up for review.	$1.7 million (est.)
	Science Broadcasting	$2.336 million
	Prism Productions, Inc., "How About:" 90 second science series for commercial television (syndicated to 140 stations—jointly funded with General Motors Research Labs; NSF contribution: $0.208 million).	
	Children's Television Workshop, "3-2-1 Contact:" science programing; National Public Radio, "Science Information on Public Radio:" establishment of science production capabilities and provision for science coverage for distribution to 227 public radio stations ($0.198 million).	
Department of Defense		
Army	See tables 18 and 19 for program elements and project topics.	$73.5 million
Navy and Marine Corps	See tables 18 and 19 for program elements and project topics	$131.7 million
Air Force	See tables 18 and 19 for program elements and project topics.	$49.4 million
Total		$284.336 million

[a] Some funded with fiscal year 1980 and fiscal year 1981 moneys.

[b] CAD/CAM-Computer-assisted design/computer-assisted manufacture.

SOURCE: Office of Technology Assessment.

New Grants for Fiscal Year 1982

A breakdown of the funds that have been tentatively earmarked or committed for new projects within OE, NSF, and DOD is shown in table 25. Approximately $6.8 million are available, $5.4 million within OE. The Army has established a new Non-System Training Devices Development Program with an initial budget of $1.4 million. NSF will fund only one new project in fiscal year 1981—a $0.5 million effort to foster innovative ideas for using computers in science education. The project was conceived after NSF had been approached by several manufacturers who offered to provide free microcomputers for experimentation in educational institutions.

A revealing analysis of Federal support of R&D for educational technology in fiscal year 1981 is shown in table 26, which presents estimates of funding levels for particular types of technology. Educational television will receive more money than any other form of technology—an estimated $21.411 million, a sum that includes grants for local demonstrations. From fiscal year 1968 through fiscal year 1980, the Children's Television Workshop received grants from OE totaling $46.3 million for the development and production of Seasame Street and The Electric Company—an average of $3.56 million per year.[16] If the increased costs of television production and general inflation are taken into account, the $21.411 million Federal support level for fiscal year 1982 will clearly be insufficient to maintain the same volume of programing that previously existed. This year, OE's Office of Educational Research and Improvement (Division of Educational Technology) has plans to award only

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[16] A. A. Zucker, *Support of Educational Technology by the U.S. Department of Education: 1971-1980* (Washington, D.C.: U.S. Department of Education, February 1982).

Table 25.—New Grants for Educational Technology R&D, Fiscal Year 1982

Program	Grant description	Funding level
Department of Education		
Division of Educational Technology	Educational television projects	$2.9 million (est.)
National Institute for Handicapped Research	Adaptation of educational technology for use by handicapped; other topics to be identified.	
	Bank Street College: 26- to 15-minute programs for ITV or ETV use, plus computer game software, computer graphics, and video disk application.	$1 million (est.)
	"Careers in Electronics and Computers" (working title): two 60-minute programs that focus on opportunities for young people and displaced workers.	
Special Education Resources	None	0
Handicapped Research—innovation and development	Technology utilization projects	0
National Institute of Education	None	0
Fund for the Improvement of Postsecondary Education	Based on proposals received to date (40 percent are for education technology projects	$1 million (est.)
National Science Foundation		
Science and Engineering Education Office	"Gift Program:" (in response to gift of microcomputers offered by two producer companies) foster innovative ideas for using computers in science education.	$0.5 million
Department of Defense		
Army	Nonsystem Training Devices Development	$1.4 million
Navy and Marine Corps	None	0
Air Force	None	0
Total		$6.8 million (est.)

SOURCE: Office of Technology Assessment.

Table 26.—Federal R&D Funding for Educational Technology Fiscal Year 1982 By Type of Technology[a]

Technology	Agencies funding	Funding level
Computer-based instruction	National Science Foundation; Department of Education; Department of Defense	$5.55 million (est.)
Educational television	Department of Education	$21.411 million
Teleconferencing	Department of Education	$1.1 million (est.)
Video disk	Department of Education	$0.975 million (est.)
Electronic mail	Department of Education	$0.3 million (est.)
Satellite	Department of Education (Funding of Regional Laboratories)	$0.05 million (est.)
Calculators	Department of Education	$0.3 million (est.)
Other		$4.55 million (est.)
Total		$34.236 million (est.)

[a] Includes multiyear projects funded with fiscal year 1980 and fiscal year 1981 moneys.

SOURCE: Office of Technology Assessment.

two new educational television grants that amount to $2.9 million. Computer-based instruction (including software development) is the only technology that will be supported in fiscal year 1982 by all three Federal agencies (at a total level of $5.55 million). Other technologies, such as video disk, electronic mail, and calculators, will each receive between $0.2 million and $0.3 million in Federal support, all of it coming from OE.

Federal Support for Educational Laboratories

With the Cooperative Research Act of 1963 and the Elementary and Secondary Education Act of 1965, the U.S. Office of Education established regional centers and laboratories for educational research to focus efforts and to encourage experimentation under controlled conditions. In fiscal year 1982, NIE will provide $28 million for these centers and laboratories. Of this amount, about $335,000 will be used to support educational technology projects. The Wisconsin Center for Educational Research at the University of Wisconsin at Madison, Wis., will investigate possible uses of microcomputers in problem-solving and language skills instruction. The University of Pittsburgh's Learning Research and Development Center has initiated small curriculum software development projects in developmental reading, writing, and mathematics. Through a communications skills project, the Southwest Regional Laboratory hopes to develop microcomputer software for student use in generating, manipulating, and editing text in an interactive mode. Some of the funding for educational technology R&D projects comes from the States, as do some of the funds to support the Northwest Regional Educational Laboratory educational satellite project for R&D dissemination.

Educational Technology R&D Support by Other Nations

While the U.S. Government is reducing its commitment to develop new applications of information technology in education, a number of other countries are planning or initiating major programs. Some have succeeded in attracting U.S. researchers as major participants.

France

In January 1982, France announced plans to establish a World Center for Computer Science and Human Resources for the expressed purpose of designing personal computer systems for use in training and education projects in industrialized and Third World countries. With an initial annual operating budget of $20 million, the center staff has tentative plans to develop computer-based education projects in Senegal, Kuwait, Ghana, and the Philippines. The center will most probably receive additional financial support from those countries. Programs to retrain workers whose jobs have been eliminated through automation are also under consideration.

Some see the establishment of the center as evidence that the French Government regards the computer as an important agent of social change and that it views its development as an important factor in determining how well the French will compete with the United States in the field of microelectronics.[17] Although the center's board of directors will have international representatives, at least nine French cabinet ministers will be among its members.[18] The chairman of the World Center will report directly to President Francois Mitterand, an indication of the importance that the French Government attaches to the project.

Two U.S. scientists have accepted positions with the center. Nicols Negoponte, a professor of computer graphics at the Massachusetts Institute of Technology (MIT), will assume the post of director. Seymour Papert, founder of MIT's artificial intelligence program and developer of the computer programing language LOGO, will serve as its chief scientist.

Testifying on May 19, 1982, before the Subcommittee on Investigations and Oversight and the Subcommittee on Science, Research, and Technology of the House Committee on Science and Technology, Jean Jacques Servan-Schreiber, chairman of the World Center, described it as the first of a network of such facilities that will focus on human resource development through application of computer technology. He expressed the hope that the United States would establish the next such center, encourage the funding of others, and cooperate with France in " . . . the implementation of a policy aimed at the stimulation of worldwide economic activity and employment."[19]

European Commission

The European Commission, the independent policy-operating body of the European Community, plans to launch a 10-year, $1.6 billion program to aid research in computer-related technology. Funding will come from the commission, from the industrial sector, and from other sources. These funds will be distributed as grants to European research groups, private laboratories, and universities for concentrated efforts in such areas as office technology, factory automation, software, advanced microelectronic chips, and aritificial intelligence. European researchers and business representatives will discuss the project during 1982. Plans call for the program to be initiated before the end of 1983.[20]

United Kingdom

Britain believes that its future role in international markets will be largely affected by the investments it makes now in fostering the development of information technology. With this in mind, the British Government is establishing a comprehensive policy for information technology that will have the following key elements:

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[17] "Micros Are This Year's Paris Fashion," *New Scientist*, Feb. 25, 1982, p. 486.

[18] M. Schrage, "France Plans Computer World Center," *Washington Post*, Jan. 28, 1982.

[19] J. J. Servan-Schreiber, testimony of Jean Jacques Servan-Schreiber, before the Subcommittee on Investigations and Oversight and Subcommittee on Science, Research, and Technology, Committee on Science and Technology, U.S. House of Representatives, May 19, 1982.

[20] "EEC Stakes 855 Million on Tomorrow's Computers," *New Scientist*, Jan. 7, 1982, p. 5.

- provision of a national telecommunications network;
- the development of a statutory and regulatory framework designed to encourage further growth of information technology products and services;
- initiation of actions to create an awareness of the inherent advantages of information technology and to stimulate interest in utilizing new services and equipment; and
- direct support to the development of new products and techniques.

A Ministry for Information Technology has been created within the Department of Industry, to serve as the point of coordination for all government activities. Apart from designating 1982 as Information Technology Year, the British Government has launched a $1.2 million public awareness campaign. It is, moreover, in the process of initiating a variety of projects, including one designed to place a microcomputer in every secondary school by the end of 1982, and another—known as the Microelectronics in Education Program—that will provide instruction to teachers on the use of the computer as a classroom learning aid.

Clearly, the actions that nations are taking to encourage basic research and product-related R&D in information technology are in accordance with the ideas U.S. researchers have about Government support and participation. In hearings before the Subcommittee on Domestic and International Scientific Planning, Analysis, and Cooperation of the House Committee on Science and Technology, held in 1977, researchers from educational institutions and other nonprofit settings, as well as representatives from the computer hardware and software industry, advocated the establishment of large-scale, "critical mass projects" through which continued innovations in educational technology could be achieved. A number of participants cited the need for continuity in funding and ongoing support for projects lasting from 6 to 10 years rather than for the traditional 1- to 3-year cycles characteristic of Federal funding. They frequently mentioned the vital role that the Government plays in fostering development of the technology and in eliminating constraints that inhibit applications. William C. Norris, Chairman and Chief Executive Office of Control Data Corp., one of the U.S. firms most active in computer-based education, underlined the importance of the Federal Government's role in encouraging, through funding and other means, cooperative R&D efforts between universities and industry, in order to ensure that basic research is undertaken and new products continue to be developed and disseminated to specific markets. Recommendations made at the hearings also included the establishment of a national center and/or regional centers that would focus on further developments in educational technology.[21]

Implications of the Present Federal Role in Educational Technology R&D

Commitments made to R&D for educational technology at the level of fiscal year 1982 funding do not permit the Federal Government to continue to serve as a major participant in, and catalyst for, new research activities. Given decreased Federal funding levels and staff shortages, the degree to which the university community will participate in the future is also in question. Thus, private industry will have to provide the largest percentage of research dollars, and to perform most R&D functions. In a climate of increasing international competition, in which industry will tend to invest more in product-related R&D that ensures return on investment rather than in more fundamental research, the future of U.S.-based basic research and other nonmarket-oriented efforts is in doubt. This situation contrasts sharply with the European examples where national governments are becoming active participants in establishing national programs. In Third World countries, governments are also eager to utilize information technology to improve their training and educational programs.

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[21] Committee on Science and Technology, U.S. House of Representatives, *Computers and the Learning Society,* hearing before the Subcommittee on International Scientific Planning, Analysis, and Cooperation, Oct. 4, 6, 12, 13, 18, and 27, 1977 (Washington, D.C.: U.S. Government Printing Office, 1978).

Plans are underway at OE to establish an Educational Technology Initiative, a $16 million program that, over a 3-year period beginning in fiscal year 1983, will focus on the development of educational software. This initiative will also set up lighthouse school demonstrations, where applications of educational technology may be observed by school administrators and others, and an information clearinghouse and exchange.[22] By leveraging funds, the proposed program seeks to attract matching funds from industry to develop educational software to meet school specifications. Given past levels of Federal involvement in such public-private R&D projects, it is questionable whether the Federal contribution of $3.3 million extended over a 3- to 5-year period will be enough to stimulate private investments.

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[22] Department of Education, Office of Educational Research and Improvement, *FY/83 Program/Budget Plan: Secretary's Technology Initiative* (Washington, D.C.: Department of Education, February 1982).

Present and Future Support for Educational Technology R&D

Arguments favoring Federal involvement in R&D stress the riskiness of investment in these early stages of market development and the fact that much needs to be learned about how to use these new media most effectively. Some of the case studies that follow suggest that Federal support has been a critical factor in bringing experiments such as Sesame Street and PLATO to the point where commercial success stimulates private interest. If Congress decides to emphasize R&D in educational technology, several issues must be resolved.

- *Source of Funding.*—The Federal Government is only one of several potential sources of R&D support. Are there ways of providing Federal support that encourage investment in R&D by private industry, foundations, and even local and State education agencies? Mechanisms for coordinating and pooling research funds from multiple sources have to be explored.
- *Level of Funding.*—Several experts have expressed the opinion that current funding is far below the critical level necessary to make significant and rapid improvements in the state of the art. They point out that the French World Center has a starting budget of over $20 million per year and that previous Federal efforts in educational technology were funded at a significantly higher level than at present.
- *Stability of Support.*—Perhaps more important than the particular funding level is the fact that in order to encourage the formation of high-quality centers of research and to foster the entry of capable researchers into the field, there will need to be a long-term commitment to support R&D at whatever level is deemed appropriate.
- *Type of Research.*—There are four broad areas of research in learning technology: 1) research on the hardware technology itself to develop appropriate educational devices; 2) research on software development and courseware authoring techniques, such as how to make the best instructional use of information technology; 3) research on human-machine communication and interaction such as that on languages, keyboard and screen design, and the use of graphic images to transfer information; and 4) research on cognitive learning and on how individuals interact with educational systems.

- *Basic Research or Development.*—The proper role of the Federal Government in funding research, however, is more clearly established in basic research and becomes less clearly so as the work is more developmental in nature. The closer a project moves to developing a potentially marketable application, the more these issues come into focus:
  - —what is the appropriate overlap between Government and private funding, and
  - —assuming that a Government funded project turns out to be a commercial success, how can it then best be moved quickly into the private sector?

Case Studies of Landmark R&D Dissemination Efforts in Educational Technology

This section includes four case studies of educational technology projects initiated partly or wholly with Federal funding. These projects have significantly affected the educational process, in some cases broadening the definition of what education is and where it can take place. The first case study describes the formation of the Children's Television Workshop; the second, the development, production, and marketing of PLATO, a computer-based learning system; the third, the establishment of the Computer Curriculum Corp. as an outgrowth of federally supported, university-based research in computer-based instructional systems for schools; and the fourth, the creation of CONDUIT, a nonprofit group that evaluates, packages, and distributes computer-based learning materials to secondary and postsecondary institutions.

Case Study 1: The Children's Television Workshop

The Children's Television Workshop (CTW), the creator of the prize-winning educational television series, Sesame Street and The Electric Company, was the first television program producer to design educational programs on a large scale specifically for preschool children. The CTW experience illustrates the highly successful use of technology for educational purposes, a substantial Federal Government investment and role, and the creation of a unique organization. It can therefore provide useful insights into and lessons about, the interrelation of public policy, technology, and education.

Context

CTW was formed in 1968 at a time when early childhood studies had established how important the preschool years are in laying the foundation for subsequent intellectual development. It was a period when educators, increasingly aware of the exceedingly large number of hours that young children were watching TV each day, were becoming concerned about the kind of programing being offered. There was at the same time a growing sensitivity to the disparity in school readiness between advantaged and disadvantaged children.

CTW decided to experiment with a show that would attempt to capture the attention of young children, particularly those from low-income families. It was suspected that children from disadvantaged families watched TV even more than middle class children. Surveys showed that 90 percent of all families with incomes below $5,000 owned at least one television set and that disadvantaged families with preschool children had their sets on for an estimated 54 hours per week.

Budget and Organization

In 1968, CTW was set up as an autonomous unit within National Education Television, which served as a corporate umbrella for the purpose of receiving grants. Two years later, it became independent as a nonprofit corporation. The budget for its initial 2 years was $8 million—the first year for preparation, and the second for production and broadcast. The U.S. Office of Education agreed to pay 50 percent of this cost; the remainder was funded primarily by the Ford Foundation and the Carnegie Corp.

The present CTW budget is around $33 million, most of which is spent to pay the costs of its nonbroadcast enterprises such as the printing and postage for three widely circulated magazines.

Foundation support has tapered off, and Federal support for Sesame Street ended in fiscal year 1982. As a result, the staff was recently cut back, and CTW's community outreach program was reduced. While new programing continues for existing series, no new large-scale projects have been announced.

An effort has been made to generate new revenues through a whole series of products based on CTW programs. These include books, records, toys, games, and even clothing. CTW estimates that in 1982, royalty revenues from the sales of nonbroadcast materials will total $22 million, $16 million of which will go to cover costs, leaving an anticipated net revenue of $6 million to be applied to the continuing cost of Sesame Street and other educational projects.

CTW has also established a unique educational park known as "Sesame Place" in Bucks County, Pa. Designed for children age 3 and up, it is of special interest because, in addition to having dozens of outdoor play elements and indoor science exhibits, it provides 60 Apple computers on which children can plan educational games developed by CTW. A second park was opened in the summer of 1982 near Dallas, Tex. CTW also has a traveling roadshow called Sesame Street Live.

As another potentially important new revenue-producing venture, CTW is developing and marketing game software for the personal computer. While these games are intended to be educational, one of their design criterion is that they also be entertaining.

CTW Programs

CTW created three highly successful large-scale educational series for children: Sesame Street, The Electric Company, and 3-2-1 Contact. Sesame Street, the pioneer program, demonstrated that high-quality education programs could win mass audiences of children. After Sesame Street, CTW went on to develop another equally successful show in its reading program for young children called The Electric Company. Supplementary reading materials to reinforce both these programs were developed for students, teachers, and parents.

The most recent series, 3-2-1 Contact, was designed for children between the years of 8 and 12. Its aim was to acquaint children with the nature of scientific thinking and with some areas of scientific investigation. The initial season ran daily for 26 weeks. Five programs per week were built around a weekly theme such as light/dark, hot/cold, growth/decay, and fast/slow. As with Sesame Street and The Electric Company, actual production was preceded by careful study beginning with an examination of need. It was discovered, for example, that half of the States had no science requirements for teacher certification at the elementary school level, and that only 6 percent of 9-year-old students ranked science as their favorite subject. The developmental stages of 3-2-1 Contact involved 6 months for feasibility studies, 6 months for testing and development, and 6 months for production.

CTW also produced Feeling Good, an adult series on health; Best of Families, a series in American social history; and a commercial television family special: The Lion, the Witch, and the Wardrobe, which won an Emmy as the outstanding animated television special of the year.

CTW considers none of its program series to be a finished product. Programs are constantly brought up-to-date, expanded, and revised for greater audience appeal and educational impact. Sesame Street went on from its emphasis on cognitive learning to include such societal goals as cooperation, conflict resolution, and fair play. Sesame Street and The Electric Company programs were also adapted to the special needs of the mentally retarded, the deaf, and the Spanish speaking. 3-2-1 Contact was incorporated into museum programs throughout the country and was made an integral part of the Girl Scout program for obtaining a special 3-2-1 badge. 3-2-1 Contact has been used in prisons, and Sesame Street has been used with the refugee boat children.

Impact of CTW

With Sesame Street and The Electric Company, CTW proved that skillful educational programing could win a mass audience. Their combined audience in the United States has been estimated at 15 million people. They are the two most watched programs on public television. Sesame Street regularly commands a larger audience among 2 to 5 year olds than any other commercial television program. Studies conducted in low-income neighborhoods suggest that from 80 to 90 percent of the children watch. CTW programs are also cost effective. Cost per viewer per program, for each CTW program, has been less than 1 percent per day.

Teachers throughout the United States report that children arrive in school more knowledgeable and more able to master fundamental skills in reading and arithmetic. The CTW style has been copied by other television producers, and many parents and teachers have reported a change in their own thinking about education.

CTW programs are now offered in at least eight different languages and are shown in nearly 50 countries and territories. They have received 18 Emmy's, the European Prix Jeunesse, the Japan Prize, and numerous other awards and commendations. In 1979, the Smithsonian Institute's Museum of American History celebrated CTW's 10th birthday with a 3-month long exhibit.

Among the factors cited as contributing to CTW's success are:

- *Generous Funding.*—The large initial funding for Sesame Street was essential for achieving high quality.
- *Planning.*—Each project has been planned very carefully and in great detail, beginning with a feasibility study and working through all stages; from the time a CTW project was first considered to the time it is first broadcast typically takes 2 years.
- *Producer Freedom.*—CTW had complete control over the content and design of its program, and could make all programing decisions without outside interference.
- *A Delivery System Already in Place.*—Almost every household had a television set and the broadcast time and transmission facilities were available through the public broadcasting system.
- *Available Professional Expertise.*—CTW could draw from commercial television.
- *Personnel.*—The project was initiated by highly competent, creative people.

Case Study 2: Development, Production, and Marketing of PLATO

PLATO, a computer-based education system designed for use with conventional and multimedia learning aids, was developed at the University of Illinois under the guidance of Donald Bitzer. Since its initiation in 1959, it has been supported by a combination of Federal, State, industrial, and private agencies and organizations. Most of the financial assistance was provided by NSF with some funding from OE. When OE discontinued its support, several corporations also withdrew theirs. Control Data Corp. (CDC) was eventually licensed by the University of Illinois to produce and market the PLATO system.

CDC is a worldwide computer and financial services company based in Minneapolis, Minn., employing 60,000 people and marketing products and services in over 47 countries. In 1981, CDC's net earnings totaled $171 million on combined revenues of $4.2 billion. Since 1962, the company has invested more than $900 million in its educational products and services.

CDC maintains that, in addition to its other profitmaking activities, it can also make a profit by addressing itself to the most intransigent problems of our society. In cooperation with business, educational, and religious organizations and government agencies, CDC has developed projects relating to the inner city, low achieving students, prison inmates, small businesses, and independent farmers. Some projects are entirely devoted to education and some are only partially so. The PLATO learning is heavily used in many of these efforts.

PLATO Computer-Based Education

In 1981, there were 18 PLATO systems, 10 owned and operated by CDC and 8 by universities. Nine of the eighteen are located in the United States and Canada, and nine are overseas. The cumulative number of terminal contact hours on PLATO IV passed the 10 million mark in 1979. This is by far the most extensively used system of computer-based instruction in the world.

A PLATO system consists of one large central computer that connects to many terminals by long-distance telephone lines or satellite. There is no technological limit to how far a terminal might be from the main computer; hundreds of miles is not uncommon. At the terminals, individuals or small groups of students can have access to a wide range of instructional materials, which include presentations, drills, tutorials, dialogs, simulations, problem-solving, and games.

PLATO learning can also be delivered on microcomputers using disks that store the learning materials. In 1981, CDC announced its own microcomputer, the Control Data 110, which runs PLATO as an application. The 110 also serves as a small business computer and can be hooked up to the central PLATO system to deliver PLATO learning on-line.

The nature of the conversation or interaction between a student and the computer depends on the way in which the author has written the instructional materials. Generally, the interaction has these characteristics:

- The student gets immediate response from the computer whenever the student asks or answers a question.
- The computer adjusts its lesson to meet the particular needs and abilities of the individual student at that moment.
- The computer keeps track of what the student has already learned.
- The student can work in private without fear of exposing his weakness to other people.
- The student can use the computer to assist him in visualizing ideas through graphics, computations, examples, and simulations.

In addition to interacting with the computer program, the student can use the PLATO network to discuss his studies with teachers or other students, even though they may be physically located thousands of miles away. The computer can diagnose, evaluate, teach, test, and keep records. The terminal screen is tactile-sensitive. If a child is learning to read and does not know a word—e.g., "mouse"—he can touch the word and, as the word mouse is spoken, it will be replaced by a picture of a mouse.

Availability and Use of PLATO

In 1981, about 6,000 PLATO terminals were used in diverse settings. One type of setting was the CDC Learning Center, which is open to the general public and which offers courses from a third grade level to advanced postgraduate work. There are 115 CDC Learning Centers throughout the United States, the subjects taught at these centers include business, industry, and computer-related subjects as well as foreign languages, English, math, sciences, education, psychology, the arts, and career counseling. Learning centers offer business, industry, government agencies, and schools a cost-effective alternative to traditional training programs. A company or agency can have PLATO programs written or adapted to their particular training needs and have the programs made available to their employees throughout the country.

Customers can install terminals that deliver PLATO CBE, either on-line or off-line, on their own sites. Schools have terminals onsite in all cases. With the release of PLATO courseware to other micros, however, the use of PLATO learning will be able to increase greatly at a highly reduced cost.

Industry

To date, the primary use of PLATO has been for inservice training in industry. Courses include basic management training, accounting, economics, equipment operation and maintenance, powerplant operation, computer fundamentals, and computer programing.

Examples of training needs to which PLATO has been adapted include:

- United Airlines uses PLATO to bring 367 new trainees each year up to entry level for transitional training. The PLATO-assisted program takes 11 days compared to the 15 days formerly required without PLATO. United Airlines estimates that it saves $29,827 per year by using the PLATO systems.
- Control Data Institutes train 7,000 programers, operators, and technicians yearly for the computer industry. In the United States, 60,000 people have received this training since the first Control Data Institute started in 1965. More than 50 percent of the training is on PLATO.
- The Navy successfully adapted CDC's Basic Skills Learning System to train recruits at the Navy Recruit Training Center in Orlando, Fla. With the help of PLATO, two to three times the usual number of recruits were trained by the same-sized staff, and they completed their required course work in fewer hours. This PLATO program was administered by regular noncollege Navy personnel after only 2 weeks of specialized training.

Higher Education

Many colleges and universities use PLATO CBE. Some examples of the different ways in which PLATO has been integrated into educational curricula are:

- The University of Colorado uses PLATO for developmental English, physics, electrical engineering, accounting, educational psychology, and astronomy.
- The Reading Pennsylvania Area Community College offers PLATO courses in basic skills, training for local industry, and enrichment programs in math, Russian, and other subjects for exceptionally advanced high school students.
- The University of Delaware uses PLATO in its School of Music to provide drill and practice with musical notes played by a synthesizer connected to the terminal and offers PLATO courses in dressmaking, nursing, and agriculture.
- The American College offers courses in life insurance and related financial sciences to students in all 50 States and 12 foreign countries. The networking power of PLATO is ideal for this widely dispersed student body.
- The University of Quebec has eight terminals in almost continual operation on the Trois-Rivieres campus. Faculty members create their own lessons in French, chemistry, English, physics, geometrical optics, data processing, and psychology. It sometimes takes as long as 250 hours to produce a 60-minute lesson.

Public Schools

Although CDC is interested in introducing PLATO into public elementary and secondary institutions, PLATO has not been utilized by public schools primarily because of its cost. However, with PLATO learning new being delivered on micros—both on CDC microcomputers and those of other companies—costs may drop substantially. One example of a successful application of PLATO is in an innercity school in Baltimore. In 1979, 200 of Walbrook High School's 538 seniors failed the City of Baltimore math and reading proficiency tests. After 60 days of using PLATO, all but nine passed the test. PLATO has helped Walbrook's low achieving students to increase their academic levels as many as three grades in 1 year.

Today, 180 Walbrook students each receive 25 minutes of PLATO instruction daily on one of the school's 12 terminals. At midterm, a second group of 180 students is chosen. Thus in 1 school year, 360 of the school's 2,350 students will have received PLATO-assisted instruction. In addition, two junior high schools have two terminals each, and six elementary schools have one terminal each. The Baltimore PLATO project, initially subsidized by CDC, is now funded by the Baltimore City School System.

Special Populations

American Indians.—The American Indian Project of St. Paul, Minn., used the PLATO Basic Skills Program to meet the remedial educational needs of 1,200 American Indian students in 65 urban areas. Some students were able to raise their academic levels by 5 years in only 6 months of work.

Home Workers.—PLATO is used to train and provide employment for homebound, disabled employees. CDC has created jobs in programing for businesses and in developing courses for the PLATO system. The computer network makes communication possible between employers, employees, and fellow workers, thus establishing a community that can give peer support to homeworkers nationwide.

Prisoners.—In 1974, CDC chose correctional institutions as one entry point for its Basic Skills Learning System. A pilot PLATO Basic Skills Learning program was installed in the Minnesota State Prison in Stillwater. After only 7 hours of PLATO study, inmates averaged gains of 1.6 grades in reading; after 12 hours, they averaged gains of 2.16 grades in math. Students were anxious to use the computer, and here again, as in the case of the Indian program, academic success was matched by improved social attitudes. PLATO is now used in 29 correctional institutions located in 10 States and in the United Kingdom.

Unemployed.—A CDC program specifically designed for the hardcore unemployed, called Fair Break, consists of the PLATO Basic Skills courses in math, reading, and language, as well as a course in how to choose and get a job. The coursework is supplemented by a counseling and referral program that helps adult students cope with problems relating to health, finances, drugs, and interpersonal problems. The program also involves peergroup counseling. CDC provides part-time work to program participants for the duration of the course.

Assessing Benefits and Cost Effectiveness of PLATO

In attempting to assess the benefits or cost effectiveness of a given PLATO application, three factors must be taken into account: the delivery system, the implementation, and the courseware.

PLATO as a Delivery System.—While some evaluative reports criticize minor aspects of the central delivery system, most regard the central delivery of PLATO learning as being exceptional, and believe that its full potential is still unrealized. The major criticism of PLATO as a delivery system has been its cost. The most clear-cut beneficial or cost-effective uses of PLATO are those in which:

- Educational opportunities are delivered that would otherwise be unavailable to the learner population in question.
- Instruction is brought to learners who would otherwise have to be transported to a distant site for training.
- Needed skills and knowledge can be acquired more quickly through a PLATO course than they can through an alternative instructional method.

Implementation of PLATO.—Implementation refers to the setting and manner in which instruction is taken—the institution, the learner population, the role and personality of the teacher, the relationship of the PLATO learning experience to other instructional components, the motivational aspects of the environment, and so forth. In a study conducted by the Educational Testing Service, the use of PLATO in four community colleges was found to have no significant effect on student attrition, student achievement, or student attitudes toward their academic experience. Participating instructors tended to view PLATO favorably, but teachers judged their PLATO students less favorably than their non-PLATO students in ability, motivation, and achievement.

Implementation in Military Training Settings.—The cost effectiveness of computer-based instruction in military training has been investigated by analyzing 30 studies of computer-based instruction, seven of which used PLATO; the rest of which used all other computer-based systems. It was concluded that, on the whole, computer-based instruction reduced the time normally needed by students to complete courses using conventional instruction by 30 percent. The difference in the amount of time saved by individualized self-paced instruction compared with computer-based instruction was found to be relatively small. The PLATO system was not found to be more effective than other computer-based systems' studies. Furthermore, according to two cost-effectiveness evaluations, the Army PLATO IV system was judged to be less effective than individualized (noncomputerized) instruction.

Implementation in College Settings.—A comprehensive analysis of computer-based college teaching was made that included 59 studies of which an unspecified number were of PLATO courses. Although about 20 different characteristics of these courses were analyzed, they were not classified according to the particular delivery system that was used (e.g., PLATO, TICCT). It was found that a typical computer-based institution class raised student achievement by about one-quarter of a standard deviation unit.

Courseware.—The term courseware refers to the programs on PLATO that contain both the content and logic of the instruction. An extensive variety of different kinds of courseware have been developed for this system.

Seven evaluation studies of the PLATO Basic Skills Learning System have indicated that the curriculum is at least as effective as some conventional methods in providing remedial instruction in math and reading. In one such study, 236 high school students in Florida received remedial instruction in mathematics via PLATO. The median gain for all students was 1.5 grade equivalents after they have spent an average of almost 20 hours in the math lessons. This equivalent equates to about 1.0 grade equivalent gain for 13 hours in the curriculum.

Because there was no control group in the Florida study or in several of the other evaluations of the basic skills curriculum there is no way of knowing whether other instructional methods might have been as effective or as cost effective. Where control groups were included in basic skills evaluations, the results have been mixed or inconclusive.

Students using PLATO Basic Skills courseware tend to cover subject matter more quickly than do control groups. For example, at a Minnesota correctional facility, 20 reading students gained an average of 1.02 points in test scores after 9.6 hours of PLATO-assisted instruction. The control group of 6 students that had 15 hours of instruction gained 0.08 points. Twenty math students gained 1.75 points after 17.6 hours of PLATO. After 25 hours of non-PLATO instruction the corresponding 6 control students gained an average of only 0.35 points. In a comparison of 15 PLATO students with 15 controls at Bexar Detention Center, the PLATO students gained 1.13 points in math tests. The control group, after more than twice the amount of instruction time, gained only 0.19 points.

PLATO and other computer-based instruction methods have capabilities that provide unique learning experiences that are impossible or impractical using other means. One example is a cardiology course at the University of Alberta, Edmonton, Canada. These programs can simulate virtually any heartbeat. The student is aided by a "stethophone," an electronic stethoscope that amplifies the low-frequency sounds of the heart, and a terminal screen that displays a diagram of the patient's body. The student can hear heart sounds indicative of virtually all coronary conditions, providing an experience which traditionally would have required first visiting the radiology department to review X-rays, and then the wards to see the patient. Because of the wide variety of cardiac dysfunctions, the urgent nature of cardiac lesions, and the large number of medical students, students normally would not have the opportunity while in medical schools to observe every kind of heart disease. Previously, classes as large as 118 students would spend 50 hours in a traditional lecture environment. With the PLATO system, that instructional time has been reduced to an average of 20 hours and with a higher learning rate.

Case Study 3: Computer Curriculum Corp.

Computer Curriculum Corp. (CCC) is a for-profit company that develops and markets computer-assisted instruction (CAI) systems to schools. It was founded in 1967 by Patrick Suppes as a marketing outgrowth of R&D in CAI that began in 1963, at the Institute for Mathematical Studies in the Social Sciences at Stanford University. The institute's first instructional program was a tutorial curriculum in elementary mathematical logic. A preliminary version of its elementary mathematics program was tested in 1964. The first use of CAI in an elementary school took place in 1965, when fourth-grade children were given daily arithmetic drill-and-practice lessons in their classroom on a teletype machine connected by telephone lines to the institute computer. (Before that, the children were transported to the campus.)

During this time, the institute engaged in R&D on the use of CAI in teaching reading. In 1964, this effort was developed into the Stanford Initial Reading Project, the purpose of which was to provide a comprehensive, individualized curriculum that would improve basic reading skills. First, however, the project analyzed the obstacles encountered by culturally disadvantaged children in acquiring reading skills.

CCC Product Development

With private financing, CCC began developing a marketable CAI package based on the research that had been done at Stanford. By about 1973 the hardware became inexpensive enough to develop a system that could be marketed at a reasonable cost. Thus, CCC started as a marketing organization in about 1974. At that time, about 20 schools throughout the country were using CCC's curricula. During the 1970's, CCC had the only commercially viable and extensively validated computer-based curriculum for elementary schools.

CCC Products and Services

The CCC staff—about 200 employees—provides a turnkey system that includes computer hardware, software, curriculum, and support services (e.g., teacher training and equipment maintenance). A typical system in a school has about 16 terminals in a CAI laboratory, although this amount varies per school.

The curricula consist of drill-and-practice courses that supplement regular instruction in basic skills, primarily in reading and mathematics. In each course, students use the drills for 10 minutes per day. The three most widely used curricula are the mathematics strands, grades 1-6; reading, grades 3-6; and language arts, grades 3-6. Newer courses, such as reading for comprehension and problem solving, are rapidly being adopted.

Funding for R&D

Initial support for the work in elementary mathematics and reading came from a private foundation and was followed up by support from NSF and OE. Since 1963, NSF has supported work with elementary school gifted children and OE funded the reading project at $920,000 from 1964-67. From 1966-68 OE supported related work in CAI at Stanford. Work with disadvantaged students was supported by title III of the Elementary and Secondary Education Act of 1965, and work with the handicapped, especially deaf students, was funded by the Bureau of Education for the Handicapped from 1970 to 1973.

A reoriented project in elementary reading and math was conducted from 1967 to 1970 with a grant from NSF. Its aim was to design and implement a low-cost CAI curriculum that would act as a supplement to classroom instruction. Because the institute lost its Federal R&D support in elementary and secondary curriculum development after 1970, it had to reuse the elementary school curricula, making some special applications for hearing-impaired students. The institute then turned most of its attention to the development of university-level curricula.

Impacts

Nearly 1 million students have used CCC curricula over the past 10 years. In the 1981-82 school year, about 200,000 students from 30 States, most of whom are from disadvantaged homes in inner-city and rural environments, used them on a daily basis. CCC educational materials are paid for with title I and other Federal categorical aid.

Evaluation Studies

CCC curricula have been extensively evaluated by many groups, including individual school systems. A wide variety of populations were studied including inner-city students; students in different sections of the country; rural students in Appalachia; American Indian students in New Mexico; and bilingual, deaf, and mentally retarded students.

The studies have shown that, when used as recommended, CCC's elementary CAI curricula are effective in increasing student achievement levels. Studies comparing gains of CAI students with gains of non-CAI students show that the curricula serves as an effective form of supplementary instruction. Studies comparing CAI programs with other supplementary programs suggest that CAI participants are more likely to meet achievement objectives. Longitudinal data indicate that achievement levels can be expected to increase steadily over several years of CAI participation and that over summer holidays students do not seem to forget the concepts reviewed.

The studies also showed that several benefits can be associated with the use of CCC curricula. First, because of the categorical aid provided by the Federal programs, CAI was introduced on a broad scale among disadvantaged students, including those that come from low-income backgrounds, that are members of minority groups, or that are handicapped. Traditionally, innovation takes place in affluent schools. Second, through the detailed and highly individualized feedback provided by the computer, students acquire habits of precision in their work. Third, increased student motivation and decreases in vandalism and truancy were reported. Finally, students learned basic skills in reading and math.

Evaluations led to the following findings:

- Federally supported R&D had a major impact on the state of the art in computer-based learning and teaching. Support from OE and NSF R&D at Stanford University significantly influenced the development of curricula and methods of computer-based learning.
- The focus of the Elementary Secondary Education Act on the disadvantaged resulted in the development and implementation of high-technology systems that are effective in providing such students with basic skills.
- Numerous evaluations of the use of CCC curricula by a wide variety of students have all clearly demonstrated that, when used as recommended, they are effective in increasing achievement levels in basic skills.

Case Study 4: CONDUIT

CONDUIT is a 10-year-old nonprofit organization that packages and distributes high-quality computer-based instructional materials to colleges, universities, and secondary schools. In 1971, when CONDUIT was conceived, the major barrier to instructional computing was a lack of quality learning materials and computer software. Although materials had been developed at universities and colleges, they were being used only at the originating institution. No organization existed to distribute instructional programs. Because there were so few programs available, there was no visible market large enough to justify investment by commercial publishers. Without distribution mechanisms or author incentives, few high-quality materials suitable for distribution were being developed.

Established as a partial solution to this problem, CONDUIT was intended to provide the organizational link that would search for materials, test and review them, revise them so that they could be used at different institutions or on different computers, and distribute these packages to other institutions.

Profile of CONDUIT Today

CONDUIT has received support from NSF and the Fund for Improvement of Post Secondary Education (FIPSE). It distributes NSF educational materials that are reviewed, well documented, programed for ease of transfer to different computers, and kept up-to-date. The instructional materials are all reviewed by experts in each subject area for conceptual validity, instructional usefulness, and overall quality.

A typical institutional package consists of a computer program written in BASIC or Fortran, a student guide explaining objectives and methods of its use, an instructor guide illustrating course applications, notes explaining how to install the program on the computer, and the programs written in a form that can be read by the computer. Programs are provided both for use on small personal computers and for use on the large timesharing computers typically found on university campuses.

As of August 1981, CONDUIT distributed about 100 different packages for use in college and precollege courses in biology, chemistry, economics, education, geography, humanities, management science, mathematics, physics, political science, psychology, sociology, and statistics. CONDUIT has gained an international reputation, distributing nearly 9,000 packages to 1,500 institutions in all 50 States and 12 foreign countries.

Budget and Financing

CONDUIT currently operates on a monthly budget of about $30,000. Two-thirds of this amount is derived from revenues from the sale of packages and other publications. One-third, or about $10,000, is provided from grants from NSF's Office of Science and Engineering Education Directorate and FIPSE. Since its inception in 1971, CONDUIT has received about 2.5 million of support from NSF.

Benefits

The direct beneficiaries of CONDUIT operations include students, teachers, and authors; commercial publishers; and other groups benefit indirectly.

- About 1 million students have benefited from using CONDUIT materials, based on conservative estimate of 120 student users per package. (At a large university, one package might be used by hundreds of students over several years.)
- At least 18,000 teachers have benefited from the availability of CONDUIT materials, at an average of two teachers per package. Because CONDUIT materials are so well documented, teachers may readily tailor the materials to fit their own course and teaching style.
- Authors of computer-based learning materials also benefit from CONDUIT. Over 2,000 copies of CONDUITS guidelines for authors

have been distributed and over 100 have had their materials packaged. Authors are rewarded by having their materials widely used, and they receive royalties on sales.

- Commercial publishers are also indirect beneficiaries. Now that the commercial viability of instructional computer materials has been demonstrated, commercial publishers have become more interested in marketing such materials.
- CONDUIT serves as a useful model to other groups both within the United States and in other countries. The Northwest Regional Education Laboratory drew on CONDUIT expertise in establishing MicroSift to evaluate educational software for precollege applications. The British have drawn heavily on the CONDUIT model in establishing a similar network.

Findings

- *Sustained Support.*—CONDUIT received sustained support at somewhat below half a million dollars per year, from NSF for several years before there was any significant payoff.
- *About 40 percent of CONDUIT packages were originally developed under Federal grants.* Thus, it has provided an important dissemination function for curriculum development work.
- *It is possible for the Federal Government to make a major contribution to improving education through a minimal dollar investment, by the creation of an appropriate organizational entity.* By 1972, numerous studies had concluded that no existing organization could perform the functions necessary to break the cycle of barriers to development and dissemination of educational computing materials. A new kind of organization would be needed. Many difficulties were encountered in attempting to establish such a new organization. A few key individuals in academia and NSF were committed to the idea, however, and it was through their sustained efforts that the organization finally became a viable entity. CONDUIT's relatively low level of Federal support, and thus low visibility for several years, was probably an advantage in working out the numerous technical, political, and educational problems involved.
- CONDUIT could not have become a viable organization had it not been able to use the revenues from the sale of packages for its continued operations. This posed many legal and contractual difficulties for NSF. However, after prolonged negotiations, financial arrangements were made that enabled CONDUIT to become close to self-sustaining.
- *Coordination With Other Programs and Projects.*—The NSF Science Education Directorate encouraged projects supported by its other program areas to collaborate with CONDUIT. This collaboration provided important links to developers of exemplary materials and also provided the development projects with guidance on how to make useful products.
- *The support of established institutions,* while essential initially, has become less important over time. CONDUIT was originally established as a consortium of major educational computing networks and university computer centers. These institutions and networks provided the testing ground and data base for the early CONDUIT investigations into the area of sharing and transporting educational software.
- It is possible to increase the supply of high-quality, marketable materials by conveying appropriate guidelines and standards to authors and developers. CONDUIT has found that as more authors and development projects use its guides, the amount of quality materials available for distribution has increased.
- From 3 to 4 years are needed in order to realize a return on investment for quality computer-based instructional materials.

This figure may be shortened somewhat as the number of computers increases. However the present situation is such that the time period required for return on investment is too long for most commercial publishers.

- In creating and demonstrating the market for high-technology materials, quality of products is more critical than quantity.

Chapter 8

Conditions That May Affect the Further Application of Information Technology in Education

The development of good-quality software is a major barrier to the educational application of information technologies. Here at Oxford High School, Oxford, Mass., educators are preparing course material for a summer workshop for computer educators from across the State of Massachusetts. The conferees review published material as well as on-line computer software for inclusion in their courses

Chapter 8

Conditions That May Affect the Further Application of Information Technology in Education

When attempting to forecast how, when, and where information technology might be utilized in the education process, particularly by publicly funded institutions operating on the elementary, secondary, and postsecondary level, it is necessary to look at what is and what is not known about present uses and potential applications. While certain forms of information technology—television, for example—have been in use in education for a number of years and may be evaluated based on widespread applications (e.g., the programing developed by the Children's Television Workshop), other forms of technology—such as the microcomputer and the video disk—are relatively new and in what might be described as the initial stages of utilization.

Whether or not these technologies live up to their potential in educational environments such as the school, the workplace, and the home is difficult to predict, even in light of successful demonstrations made possible through public and private funding. A discussion of what is known about current conditions and common perceptions in segments of the education community where technologies have had some impact *and* a description of perceptions of hardware and software vendors about the structure and potential of the education market are the best means to gain an understanding of the circumstances that now prevail.

Available Data on Educational Applications

Since few measures have been made of how information technology is presently being applied in public and private schools, this discussion is limited to interpretations of data collected about the use of microcomputers, terminals, video cassette recorders, and video disks.

Microcomputers and Terminals

Based on results of a 1980 survey of a sample of 579 of 15,834 school districts in the United States, it was projected that about one-half of all districts had one or more computer terminals available for student use. Within these districts, approximately one out of four schools (or one-half of all public institutions on the secondary level, 14 percent of those on the elementary level, and 19 percent of the vocational, special education and other types) had at least one microcomputer or terminal dedicated to student instruction (see table 27). This number seems large in the aggregate. However, within individual school districts computer availability to individual students is severely limited. About 18 percent of the local education agencies—the majority small districts of 2,500 students or less—had no plans to initiate computer-based student instruction for the following 3 years (see table 28). It was determined that some 52,000 microcomputers and terminals were scattered throughout local school districts for student use, with microcomputers outnumbering terminals by 3 to 2.[1] A 1982 industry survey con-

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[1] *Student Use of Computers in Schools* (Washington, D.C.: National Center for Education Statistics, 1981).

Table 27.—Public School Districts Providing Students Access to at Least One Computer for Educational Purposes: United States, 1980 (table entries are school districts providing access)

	Type of school, by grade level				
Type of access	Total (at least one level) (1)	Elementary level (2)	Secondary level (3)	Combined elementary/ secondary schools and special schools (4)	More than one level (5)
At least one microcomputer or one terminal	7,606	2,196	6,161	678	1,884
			(in percents of column 1)		
At least one microcomputer or one terminal	7,606	29	87	9	25
At least one microcomputer	6,631	29	84	9	22
At least one terminal	2,973	21	99	5	25
At least one microcomputer *and* one terminal	1,998	17	95	3	15

NOTE: Column 1 represents the unduplicated number of districts providing access to computers at any level. Since some districts make computers available at more than one type of school, the percepts in cols. 2-4 include duplicated counts of districts. The difference between the total duplicated counts (cols. 2-4) and the unduplicated count (col. 1) represents the percent of districts providing computer access at more than one level (col. 5).

SOURCE: *Student Use of Computers in Schools* (Washington, D.C.: National Center for Educational Statistics, 1981).

Table 28.—Availability of Computers Within Districts: United States, Fall 1980

By number of computers per district

Number of available computers per district	Districts providing access	
	To microcomputers	To terminals
At least one	6,631	2,973
	(in percents)	
At least one	100	100
One	40	35
2-4	37	37
5-10	13	14
11-20	6	6
More than 20	3	8

By the number of schools with access, per district

Number of schools with access per district	Districts providing access	
	At elementary schools	At secondary schools
At least one	2,196	6,616
	(in percents)	
At least one	100	100
One	56	68
2-4	24	25
5-10	13	6
11-20	4	(a)
More than 20	3	(a)

[a]Fewer than 1 percent

NOTE: Percents may not sum to 100 because of rounding.

SOURCE: *Students Use of Computers in Schools* (Washington, D.C.: National Center for Education Statistics, 1981).

ducted by Strategic, Inc., provides forecasts of microcomputer usage in public and private elementary, secondary, and postsecondary schools as well as projections of microcomputer courseware sales through 1990. Assuming a total new shipment base of 36,000 units of hardware in 1980, there will have been, by the end of 1990, 2,030,000 such shipments to schools. In addition, by the end of 1990 the installed base of microcomputers will grow from 70,000 in 1980 to 8,860,000, with the average cost per unit dropping from $2,100 in 1980 to $1,100.[2] Computer courseware sales are expected to increase during the same period from $4.7 million to $257.5 million. If the projected aftermarket (the sales carried over from previous years, including courseware sold with microcomputer systems and replacement software) is factored into the projection, the total sales figure is expected to rise from $6.4 million in 1980 to $599.1 million (see table 29.)

In yet another study of the potential 1980 educational market for hardware sales, schools represented the smallest of five potential markets. The other four—in rank order—were small business, scientific, home and office, but a projected growth rate of 300 percent by 1985 would place annual sales at $145 million by that year.[3] However, by 1985, the school

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[2] The newest generation of home computers now sell for between $300 and $1,000, which has made it possible for many more parents to consider purchasing them as educational aids for their children ("The Home Computer Arrives," *New York Times*, June 17, 1982, D-1, D-6).

[3] Interview with Denis P. Hoye, Director, U.S. Client Services, Strategic, Inc., San Jose, Calif., regarding report entitled *Update on Educational Software: Converging Technologies and Strategies*, report No. 1500, 1982.

Table 29.—Total Shipments of Microcomputers in Public and Private Schools Operating on the Elementary, Secondary, and Postsecondary Levels and Forecasts of Courseware Sales

Total shipments	*1980*	*1985*	*End of 1990*
Total new shipments . .	36,000	600,000	2,030,000
Installed base .	70,000	1,630,000	8,860,000
Average cost per unit	$2,100	$1,600	$1,100
Courseware sales			
New courseware sold	$4.7 million	$77.3 million	$257.5 million
Aftermarket sales (carry-over from previous years and coursware sold with systems)	$1.7 million	$51.5 million	$341.6 million
Total	$6.4 million	$128.8 million	$599.1 million

SOURCE: *Update on Educational Software: Converging Technologies and Strategies* (San Jose, Calif.: Strategic, Inc., 1982).

market was projected to grow at a rate of 300 percent, placing annual sales at $145 million by that year.

Other factors complicate this picture of market potential. In a 1981 study of 15,442 school districts, it was found that 42 percent had at least one microcomputer (6,441) with 43 percent of these being senior high schools. Junior high and high schools with larger enrollments were found to be the most likely to have acquired microcomputers, as were those schools with per-student instructional materials budgets of over $60,000.[4]

Video Cassette Recorders and Video Disk

The growth rate of the general market for video cassette recorders is expected to be very high, based on 1980 estimates of 1.5 million recorders and 6 million prerecorded cassettes sold. However, there are no projections that differentiate the education or school market from other markets such as the home, so growth in this type of utilization is hard to predict.[5]

Views differ about the potential popularity of video disk, even in light of successful programs such as the "First National Kidisc." One study estimated that sales to all types of consumers were less than 50,000 in 1980, although manufacturers predicted that 250,000 units and 5 million video disks would be sold in 1981.[6] Another market analysis, conducted by Strategic, Inc., in 1982, suggests that by 1985 when educational programs and disks become more widely available, over 250,000 video disk players integrated with microcomputers will be in use. Again, this analysis does not isolate the school market. At present, Department of Education officials estimate that there may be less than 100 video disk units in place in schools.[7]

Climate for Use of Information Technology in the Schools

Information gathered in this study about the use of information technology in selected school districts seems to indicate that the computer-based education is far and away the most accepted at this time. As the case studies in this report illustrate, computer literacy programs for instructors and students represent the most common use, followed by drill and practice and some simulation exercises. Computer literacy courses are particularly popular in some areas on the junior high level.[8]

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[4] "Market Survey Discovers Where the Micros Are," *Electronic Learning*, March/April 1982, p. 14.

[5] "Videopublishing: Licensing, Manufacturing and Distribution," *LINK Research Memorandum*, vol. 2, No. 15, December 1981.

[6] Ibid.

[7] F. B. Withrow and L. G. Roberts, "The Videodisc: Putting Education on a Silver Platter," *Electronic Learning*, May/June 1982, pp. 43-44.

[8] A. Luehrmann, "Computer Literacy: What It Is; Why It's Important," *Electronic Learning*, May/June 1982, pp. 20, 22.

A 1980 survey of school districts sponsored by the National Center for Education Statistics (NCES) confirms the widespread frequency of computer literacy courses within schools with at least one terminal or microcomputer. NCES also cites cases where the computer has been used to improve student learning in selected subject areas and to stimulate high achievers. Less than half of the districts responding to the survey utilize the computer in remedial and compensatory programs. When sample districts contacted in the course of the survey were asked to identify operational and planning needs critical to the initiation of use or to the expanded use of computer-assisted instruction, the two most frequently mentioned were teacher training and greater variety of instructional software programs.

Approximately one-third of all districts indicated the need for assistance in program planning, technical support once programs are initiated, and financial assistance for hardware and software purchases.[9] Taken together, the OTA case studies of local school districts show that funding often became a critical factor in the use of computers in education, especially in light of reductions in Federal support to schools, as well as diminishing State and local resources. When traditional funding sources in these districts were insufficient or unavailable for establishing computer programs, computer manufacturers or foundations were approached and/or individual parents or PTAs made donations. These efforts were not equally successful, since local communities vary significantly with respect to the level of resources that they can make available for educational activities.

The lack of available courseware was also identified in the case studies as a major obstacle to initiation and/or expansion of computer education programs in schools. Often, when hardware is available and when instructors have a positive view of it, the lack of commercial courseware induces teachers to create their own courseware either through use of school purchased authoring systems or other means. The quality of this courseware varies significantly, frequently because instructors have mastered—usually on their own initiative—only the basics of the authoring system or programing language.[10]

In some instances, the price of the courseware may be an obstacle to more widespread computer use. Table 30 includes information on the average prices, which range from $37.00 to over $200.00, for courseware available for sale through industry, Government, and foundations.[11]

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[9] National Center for Education Statistics, op. cit.

[10] A. Bork, *Large Scale Production and Distribution of Computer-Aided Learning Modules* (Irvine, Calif.: Educational Technology Center, University of California, n.d.).

[11] *The Educational Microcomputer Software Market* (Oak Park, Ill.: TALMIS, 1981).

Table 30.—The Educational Courseware Industry

	Investment		Sales		Production	
Developer/distributor	Total	Average	Total	Average/median	Number of products	Average price
	(× 1,000)		(× 1,000)			
Scott Foresman	$1,000[a]	$1,000[a]	(b)	(b)	10	$208.38
Other ED./AV Publishers	$2,121	$177	$1,3371	$99/$45	66	$203.31
Hardware manufacturers	$665	$166	$1,670	$418/$165	65	$50.75
Software houses	$1,574	$87	$4,526	$242/$100	302	$48.75
Small developers[c]	$4,800	$31	$2,500	$15/$10	1,500-2,500	$37.73
Government foundations	$1,100	(d)	$600	(d)	111 (sample)	$60.00
Total	$11,260	$40	$10,667	$37/$50	2,000-3,000	$50.03

NOTE: All data provided is for the period July 1980 through June 1981 only. Only products available during that period are included.

[a] Published approximations: TALMIS does not report any financial information by company.

[b] TALMIS does not report any financial information by company.

[c] Extrapolated from an 11% sample (see app. IX).

[d] Data insufficient.

SOURCE: TALMIS Annual Report, 1981.

Incorporating the use of the computer in a traditional school environment—characterized by set class schedules, primarily daytime programs—can present some complex problems, even if the technology is highly valued as an effective and efficient instructional resource. Teacher resistance may also be a factor, in the use, or the extent of use, especially if limited school budgets have resulted in heavier teaching loads and less time for teachers to consider possible new pedogogical approaches. A lack of understanding of the potential of the technology in the classroom and the lack of instructor knowledge of programing or use of authoring packages for courseware development may also determine if and how information technologies will be applied.

Hardware and Educational Software Vendors: Views of the Education Market

In addition to conditions that might affect the use of technology in the schools, there are certain circumstances that may have a bearing on how producers of hardware and educational software approach the education market—in particular, publicly funded institutions.

For several years, hardware producers, especially manufacturers of microcomputers such as Tandy, Apple, and Commodore, have attempted to develop the school market while cultivating the home market. Apple and Commodore have in some instances placed micros in schools free of charge, in order to create awareness in teachers and administrators as well as to create opportunities for experimentation. In most instances to date, the companies were responding to requests of school districts. Apple and other producers have also been active in pushing for Federal legislation that would create tax incentives for the donation of computers and related equipment to elementary and secondary schools. H.R. 5573, "The Technology Education Act of 1982," introduced in the 97th Congress calls for raising the maximum allowable corporate charitable contribution from 10 to 30 percent of annual income. The bill was stimulated by Apple's offer to donate computer centers to 75,000 elementary and secondary schools—a gift valued at between $200 million and $300 million.

The central problem faced by microcomputer producers and manufacturers of other types of hardware, such as the video cassette recorder and the video disk, is that they cannot define the real potential of the school market either in its individual segments or in its aggregate form. A recent industry-sponsored market analysis for video disk, for example, cautioned against being overly optimistic about sales to all types of consumers over the next few years.[12] And, as is illustrated by the variety of different projections on microcomputer sales in general and potential sales to educators in particular, the future response to this technology is still open to question. Because of these uncertainties, using existing sales strategies with the school market as a way of testing the market potential without having to add significantly to market overhead. However, this approach may further impede potential sales, if hardware and software specialists unfamiliar with curriculum design and other aspects of school administration attempt to sell to educators.

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[12] *LINK Research Memorandum,* op. cit.

Conditions Affecting Commercial Courseware Development

A recent issue of *Electronic Learning* contains a directory of 200 educational software producers.[13] An industry-sponsored study conducted in 1980 identified some 304 educational software developers—including traditional print publishers, hardware manufacturers, software firms of various sizes, and foundations and government-sponsored projects (see table 31). Although, these numbers would seem to suggest that the educational courseware business is thriving, this is not the case. There is considerable skepticism—especially within the software industry—about the school market and its potential. Industry representatives interviewed in the course of the 1982 Strategic, Inc., survey were concerned about the difficulty of segmenting the software market in order to develop products targeted to particular grade levels and subject matter needs. Print publishers who have entered the industry are doing so judiciously in most cases by adapting existing textbooks to machine-readable form or by creating software to enhance existing textbooks and other hard-copy materials. This situation differs from that in the software development market for personal computers where there are now some 1,000 active firms and over 5,000 available programs.[14] Some hardware and software firms have developed authoring systems for use by educators, but commercial courseware now available does not meet many of the needs of local school systems. Courseware quality is also of concern to some educators. At the same time, the up-front costs associated with courseware development—estimated by one industry representative at over $250,000 per package—is more than most firms, given the market uncertainties, want to risk on an "unknown quantity." The Department of Education's recently announced "Technology Initiative" provides for matching funds to be made available to commercial software devel-

Table 31.—What Are the Industries Competing for Business

Education/AV publishers—Companies traditionally supplying books and AV products to the school marketplace.
  12 companies during the period under study (18 with products as of September 1981) including:
    Educational Activities
    Milliken
    Random House
    Scott Foresman
    SRA
    Society for Visual Education
    Sterling Swift Publishing

Hardware manufacturers—Microcomputers manufactures developing courseware products for the schools.
  5 companies, including:
    Apple
    Atari
    Commodore
    Tandy
    Texas Instruments

Software houses—Software companies selling more than $85,000 in courseware or companies with total software sales over $150,000.
  19 companies, including:
    Brain Box
    Creative Computing Software
    Data Command
    Edu-Ware
    Hartley Software
    Micro-Ed
    MicroSoft
    MUSE
    Programs Design, Inc.

Small developers—Software companies selling less than $85,000 in courseware and with total sales of all products less than $150,000.
  Approximately 250 companies (13.6% sampled for this report—see app. IX), including:
    Avant-Garde Creations
    Betamax
    Bluebird's
    Cook's Computer Co.
    Custom Computer
    Educational Courseware
    Micropi
    Teacher's Pet
    T.H.E.S.I.S.
    Teach Yourself by Computer

Foundations and Government-sponsored projects—Organized development and dissemination projects sponsored by private foundations, schools, and local, State, or Federal Government.
  Approximately 12 agencies, including:
    Apple Education Foundation
    CONDUIT
    Department of Education
    MECC
    National Science Foundation

SOURCE: *The Educational Microcomputer Software Market* (Oak Park, Ill.: TALMIS, 1981).

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[13] "Electronic Learning Software Directory," *Electronic Learning*, May/June 1982, 1-A-10-A.

[14] "Using Personal Computers," *LINK Research Report*, vol. 3, No. 1, 1982.

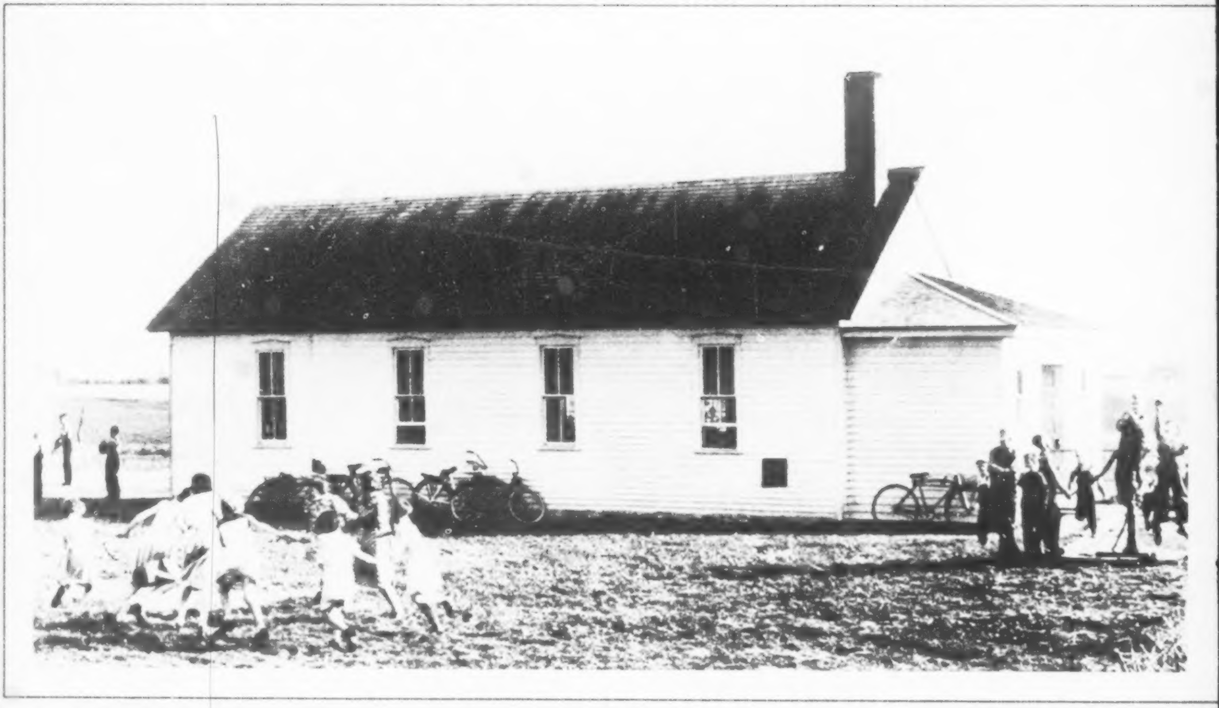
opers to assist in the creation of courseware for the schools that, because of market size, may not otherwise be developed. It is still unknown, however, whether this incentive will be sufficient to attract more commercial interest.

Summary of Current Conditions

Given what is known about present applications of information technology in the schools, it is clear that the use of computers and other forms of technology is far from being institutionalized at this time. Limited school funds, educators' limited recognition of the potential of the technology, limited computer literacy among instructors and students, and the limited variety and range in high-quality, commercial courseware have all contributed to this situation. It is difficult to predict when or if conditions in publicly funded educational institutions will change. However, expanded use of information technology—especially computers—in the home and in the workplace may result in pressure from parents, students, and even employers on local school districts to utilize technology in the instructional process.

Chapter 9

Federal Role in Education



One room school house, Brown County, Kans., 1935

Chapter 9

Federal Role in Education

The Federal Government has long been involved in encouraging or providing financial assistance to State and local educational agencies. The first Federal aid to education occurred with the passage of the Land Ordinance in 1785. Federal aid continues today in a very expanded capacity.

Most Federal education initiatives often attempted to address or remedy issues not directly related to education. For example, the early land grants were designed not only to ensure public education in the newly formed territories but also to "make public lands more attractive to prospective buyers."[1] In the 19th century, the Morrill Act was enacted to respond to the growing educational need for practical higher education in the areas of science, agriculture, and industrial training. Similarly, in 1917 a vocational education act was passed to reorient local education programs to meet the needs of changing labor markets.

By the 1950's, an expanded Federal role in providing educational services was deemed necessary. Support came in numerous forms, from grants for school construction and veteran assistance to impact aid programs. By 1965 a Federal role in education had been generally accepted. The questions raised were no longer, what role, if any, should the Federal Government play; instead, Congress sought to determine what type of investment should be made and where and how it would be most effective. The "how" signified the next important shift in the educational debate—from Congress to the courts. Today many educational issues are resolved in the judicial arena. In resolving these issues the courts rely on interpretations of the constitution as well as on recent educational legislation.

Education Legislation

The Early Years: 1642-1860

In 1642, the Massachusetts General Court passed the Massachusetts Bay Law establishing a precedent of local responsibility for education. This act and the subsequent legislation of 1647, the Old Deluder Law, which called for the creation of local public schools according to population size, were extended on a national scale in 1785 by the passage of land ordinances. Under these ordinances, moneys were set aside from the sale of lands and dedicated to the maintenance of public schools. This principle of Federal aid was consistently affirmed through a series of land grants (Statehood Acts) throughout the next century. Historians have debated the intent of the legislators in these actions—whether this effort signified a concerted attempt to preempt State rights in educational matters. Nevertheless, 98.5 million acres had been set aside for educational purposes by the Federal Government.[2]

The omission of education from express inclusion in the constitution has often been the focus of the debate concerning the extent of the Federal Government's role in the educational system. Despite its absence, the framers and other leaders of the time repeatedly called for such a Federal role. Most of the proposals, however, were directed at higher education. For President Washington, a Federal role was important for three reasons. First, there was a desire to encourage a strictly American rather than a European education. Second, he perceived that nationally sponsored education would eliminate sectional and local prejudices. And third, as indicated in his Farewell Address, Washington considered "the promotion of political intelligence as a national safeguard." Despite his urgings and the urgings of other leaders, the principal of local control as set forth in the Massachusetts Bay Law remained constant.[3]

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[1] L. E. Gladieier and T. R. Wolanin, *Congress and the Colleges* (Lexington, Mass.: Lexington Books, 1976).

[2] S. W. Tiedt, *The Role of the Federal Government in Education* (New York: Oxford University Press, 1966).

The land grants and the Enabling Acts or Statehood Acts are the most comprehensive Federal policy implemented during this time. Other individual educationally oriented projects were passed by Congress but they were aimed at specific educational concerns such as the founding in 1802, of the U.S. Military Academy at West Point.

Other Federal aid during this era took the form of surplus revenue from the Treasury Department. Moneys were distributed to the States but had no specific target. Much of the surplus revenue was channeled into the public schools by the States. Also the Preemption Act of 1841 and the granting in 1849 of lands to the States by the Federal Government converted further Federal moneys to the public schools.

During this time, universal public education became accepted. This new system of public education was accompanied by the development of a professional class of educators. By the closing years of the 19th century, this group became a highly effective educational lobby.

The Years 1860-1930

Between 1860 and 1930, the role and influence of the Federal Government in the educational system increased markedly.[4] Although this growth was, to a great extent, the result of the Civil War, it was also dictated by the Nation's shift to an industrial society, coupled with great demographic changes. More importantly, the U.S. Government in the post-War period pursued many heretofore State and local concerns of which education was just one.

Much of the post-Civil War activity was directed at rectifying regional inequities in the South. Educational measures enacted by the Republicans allowed for unprecedented Federal influence in southern institutions. Also, the illiteracy rates in the Nation, particularly in the South (42 percent rate of illiteracy), were extraordinarily high, necessitating some sort of Federal remedy.

The passage of the Morrill Act of 1862, which set aside land for the establishment of schools, signified the first such Federal aid to schools.[5] However, unlike earlier land ordinances, the act's target was institutions of higher education. The arguments in the debate over the Morrill Act are strikingly similar to those raised in educational debates today: its constitutionality, the preemption of States rights, its selectivity of focus, and the cost of the legislation, were all cited as cause for defeat. In its favor were arguments citing a demonstrated need for agricultural, industrial, and scientific and technological training, and citing regional inequities in need of remedy.[6]

The next significant Federal initiative was the creation of the Office of Education in 1867. The debate concerning its establishment, while continuing to focus on what role, if any, the Federal Government should play in traditional State and local affairs, also raised the question of public v. private education. A Federal role was seen as posing a threat to private education, and the Catholic Church lobbied extensively against the bill. The education department that ultimately emerged was empowered to collect educational data and statistics, to disseminate information concerning education, and to encourage educational endeavors. Establishing a Federal role, the creation of the Office of Education lead to the formation of congressional committees with specific educational responsibilities. In 1869, the Department of Education was relegated to bureau status and was transferred to the Department of the Interior. By 1930, the bureau was affiliated with the Federal Security Agency and later with the Department of Health, Education, and Welfare.[7]

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[3] G. Lee, *The Strategies for Federal Aid: First Phase, 1870-1890* (New York: Columbia University Teachers College, 1949).

[4] Tiedt, op. cit.

[5] Lee, op. cit.

[6] Ibid.

Two other acts were passed before the close of the century, the Hatch Act of 1887 and the second Morrill Act. The former added agricultural experimental stations to the land grant colleges, and the latter committed additional Federal funds to certain areas of higher education.

A number of other educationally related proposals were considered but not passed. These are pertinent because in many ways they formed the framework of the educational debate that continues today. The Hoar bill, introduced in 1870, sought to establish a national system of education. It proposed the creation of "satisfactory common schools, and where the States failed to do so, to authorize the Federal Government to provide them."[8] Hoar envisioned his proposal as one of ". . . protection for American economic interests. No American statesman will be unwilling to give the American workman the advantage in the great industrial competition which results from superiority of knowledge."[9] The bill did not specify Federal aid, but instead advocated that a Federal standard be set nationally for schools. As such, it represented to some an intrusion into State concerns. As with other initiatives of the time, it was specifically targeted at southern institutions.

The Hoar bill resulted in the coalescing of positions of professional groups concerned with educational issues. It also created an awareness in Congress of the issues involved in an educational debate. The National Education Association (NEA) roundly denounced the legislation because it specified a Federal role but not Federal assistance. The Catholic lobby viewed the legislation as an intrusion into Catholic educational practices and as an attempt to create one educational norm for the country. Moreover, this bill, along with others discussed below, raised issues concerning the Federal role and Federal assistance that were not resolved until 1965 with the passage of the Elementary and Secondary Education Act (ESEA). The issue of equity associated with a single national standard is in many respects similar to those parts of ESEA that allocate moneys for the educationally disadvantaged.

Two bills, the Pearce bill of 1872 and the Burnside bill of 1879, proposed a national fund for public education from the sale of public lands. The earlier bill sought to assist States that would provide free education to children between the ages of 6 and 16. The moneys raised were to be used for teachers' salaries. It is interesting to note that the bill was amended to recognize segregated schools; thus, it signaled a recognition of race as an issue in the educational debate. The latter bill differed in that land grant colleges were eligible to receive one-third of the educational grants from the land sales. In addition, the educational fund was to be supported with surplus moneys from the Patent Office. These revenues, combined with those from the land sales, were to be invested in U.S. bonds, thus establishing a permanent educational fund. Both bills failed to pass both houses. They also signified a return to the segmented as opposed to a national approach to educational concerns.

Although no education bills were passed in this decade, they did serve to raise issues central to the education debate. A concurrent development was a significant growth in organized educational advocacy groups and lobbies. For example, NEA experienced unprecedented development and growth as a professional group and lobby that could, wholesale, either support or reject education measures. This had not happened previously.

The education legislation considered in the 1880's differed from previous funding mechanisms in that it sought to provide Federal revenue for education directly to the States. It also proposed temporary aid as opposed to long-term aid. In this regard, the Blair bill, introduced five times in this decade and passed by the Senate three times, is of particular interest. It stipulated that Federal aid should be provided for 10 years to address emergency conditions in the South, that States were to supply matching funds, that funds were to be distributed according to State illiteracy rates (of persons over 10 years old), that denominational schools were to be excluded, and that the funds were to be granted within Federal guidelines.[10]

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[7] Ibid.

[8] Ibid; and S. Tiedt, *The Role of Federal Aid: First Phase, 1870-1890* (New York: Oxford University Press).

[9] Brookings Institution, *The Effects of Federal Programs on Higher Education* (Washington, D.C.: Brookings Institution, 1962); and C. Dobbins (ed.), *Higher Education and the Federal Government, Programs and Problems* (Washington, D.C.: American Council on Education, 1967).

More than any other education legislation, the Blair bill brought educational issues to the fore. None of the measures incorporated into the bill had ever been addressed together, in such a comprehensive way, before. Public awareness was stimulated and pressures were exerted. Groups that actively participated in the Blair bill debate included not only NEA and the Catholic lobby but also Protestant denominations, business interests, agricultural interests, the press, and political parties. For the first time, education was included as a platform issue by the Republican Party. The Democratic Party strongly advocated State's rights and local authority over education policy.

The first education-related proposal enacted in the early part of the 20th century was the Smith-Hughes Act of 1917. It provided matching funds to States for developing curricula in agricultural, industrial, and home economics; for administrative costs; and for teachers' salaries. This act was amended continuously until 1968. The George-Barden Act of 1946 increased the number of vocational education programs and placed administration of these programs in the Office of Education. From then on, the amendments to the legislation reduced the Federal role in agricultural areas and placed more emphasis on education for the disadvantaged.

Very little educationally oriented legislation was considered or passed during the next several decades. Between 1935 and 1943, the National Youth Administration (NYA) channeled funds to a number of institutions in support of work study programs. Over 600,000 students benefited from the NYA programs.[11] Some teachers and some school construction were funded under a variety of New Deal programs (CCC, WPA, and the Federal Emergency Relief Administration), but none of these measures signified an increased Federal role. This scarcity of legislation was due primarily to the Nations' fiscal crisis and to the fear by legislators that any program once instituted would become permanent.

Several education bills were proposed during the 1930's and 1940's that reintroduced the concept of general Federal aid, but none were successful. A bill for a student loan program, the first of its kind, passed in 1943. Juniors and seniors in high school and graduate and professional students in the fields of science, health, and engineering were eligible for federally sponsored loans if, following completion of their studies, they joined the war effort. Also, the Serviceman's Readjustment Act of 1944, the GI bill, and Public Law 16 for disabled veterans were passed. The GI bill was amended to include Korean veterans. As with the case in secondary education, a pattern of connecting educational legislation to other national concerns was also set in higher education. "Its (the Government's) interest was confined to using higher education to deal with specific national problems."[12] The legislation did revive the religious and racial controversies. Federal aid to education was mentioned in the Democratic Party platform in 1944 with the stipulation that any aid provided be administered by the States. Aid to education was not included in the Republican platform until 1948.

The Expanding Federal Role: 1950-1970's

By proposing school construction grants to local communities, most of the congressional initiative relating to education in the 1950's sought to circumvent the divisive religious issues inherent in the educational debate. It therefore became politically attractive to support this form of Federal aid, which was based on the increasing numbers of children entering the school population (baby boom.) In 1941, the Lanham Act was passed providing assistance to local communities in lieu of tax revenues to soften the impact of the war effort on State and local governments. Moneys were allocated to nursery schools and other school-related needs and were later expanded into the Impact Aid programs. The funds and scope of the Lanham Act were increased by Public Law 815 and Public Law 874, which provided construction and operating grants to State and local districts.

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[10] P. Morgan, "Academia and the Federal Government," *Policy Studies Journal*, vol. 10, September 1981, p. 75.

[11] Ibid.

[12] J. L. Jundquist, *Politics and Policy, The Eisenhower, Kennedy, and Johnson Years* (Washington, D.C.: Brookings Institution, 1968.)

The continuing debate concerning an appropriate Federal role led to President Eisenhower's establishing a White House Conference on Education in 1954. The task force recommended that the Federal Government should provide financial aid to State and local communities for educational purposes. It concluded that there was an appropriate role for the Federal Government in educational matters.

The National Defense Education Act (NDEA) of 1958 was passed as a consequence of the widely held belief that the educational system was inadequate in mathematics, science, and foreign language instruction. This belief was directly related to the successful launching of the Soviet spacecraft, *Sputnik*. Moneys were provided on a matching basis to public schools and as long-term loans to private institutions for needed equipment in these instructional fields, for curriculum development, for guidance counseling, for vocational education in defense-related fields, and for teacher training in foreign language instruction. The passage of NDEA resulted in a substantial increase in Federal aid to education. Since Federal dollars had to be matched by State and local funds under provisions of the act, the overall investment in NDEA programs was large. Between 1958 and 1961, $163.2 million in Federal money were dispersed. Approximately 75 percent of these funds were directed at developing science curricula.

The passage of NDEA led to an examination of Federal role in postsecondary education. This examination was also fostered by the increasing numbers of students entering postsecondary institutions. The educational legislation passed in the 1950's, which included postsecondary provisions, together with the legislation passed in the 1960's paved the way for major legislation in the 1970's. This steady growth of Federal involvement, culminating with the passage of the Education Amendments Act of 1972 (Public Law 92-318), was similar in process to the development of the Federal role in secondary education.

Two major pieces of legislation that Congress passed in the 1960's were the Vocational Education Act of 1963 and the Higher Education Facilities Act of 1963. The former was a much expanded version of the Smith-Hughes Act of 1917, establishing a permanent program for vocational education and setting aside 10 percent of the annual appropriations for research and development (R&D) projects in vocational demonstration projects. Concomitant to the passage of the Vocational Education Act was the passage of two amendments to NDEA, that extended the act and increased the amount of funds available for student loans. The latter provided Federal aid for construction of facilities at postsecondary institutions. This act was aptly named the "bricks and mortar act." Community junior colleges were covered by this legislation as was the construction of libraries at these institutions.[13]

The next major educational act, the Elementary and Secondary Education Act (ESEA), was passed in 1965. Its passage signaled an unprecedented entry by the Federal Government into educational affairs. Between the passage of these two landmark educational acts, Congress and members of the educational community continuously debated what an expanded Federal role in education should entail. In 1964, during the Johnson administration, the War on Poverty had become a domestic priority. ESEA, which was one outcome, focused on the poor and disadvantaged child. It incorporated a wide range of programs which, while ensuring the acts passage by their complexity, ultimately seriously hindered its effectiveness. However, a diversity of interests rallied to support the act. As with previous educational legislation, a constituency was built around a noneducational issue. At this time the three main issues to overcome in enacting any educational legislation at this time were church and state relations, State rights versus Federal control, and race relations.[14]

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[13] Ibid.

ESEA provided funds for educational R&D, for promoting educational innovation, and for assisting State agencies to establish these programs. The five original titles addressed many issues. Title I provided Federal funds to areas with concentrations of educationally and economically deprived children. Other titles of the act were designed to assist State agencies in various areas: title II—school libraries, textbooks, and instructional materials; title III—educational services and resource centers; title IV—educational R&D; and title V—State administrative needs. (See appendix of this chapter.)

Initially, two poverty indicators were used to distribute ESEA funds: based on the 1960 census: 1) the number of children between 5 and 17 from families with an income of less than $2,000, and 2) the number of children between 5 and 17 from families with income exceeding $2,000 receiving aid under title IV of the Social Security Act, Aid to Families With Dependent Children. Responsibilities for administering the act rested with both the Commission of Education and State and local education agencies.

The act was amended several times. The supplemental enactments titles focused on the issues of Federal regulation and grants, assistance to the handicapped, and bilingual education. ESEA was designed so that its programs would be administered by the State agencies with local input. The Federal role would be to distribute funds and to influence the work of the States. Accordingly, control was maintained in the State and local communities, resolving one of the major conflicts in the educational debate.[15]

Many of the amendments and changes in ESEA were effected for political as well as for educational reasons. One unanticipated outgrowth of the legislation was the use of ESEA as a means of desegregating schools. Title VI of the Civil Rights Act of 1964 stated that "no person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied benefit of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." ESEA was chosen as a conduit to enforce this title and to desegregate schools. Another reason for modifying ESEA was because its meaning was confusing. Every title involved different interested parties and different funding mechanisms and addressed different educational concerns. Enforcement and distribution of the funds was administered by the Office of Education (OE), which traditionally relied on the State and local agencies for advice and enforcement. OE was split over what this massive and complex educational legislation meant and how to implement it. Many of the changes in the act reflected an attempt to resolve these problems.

Many of the original concerns surrounding ESEA still exist; its complexity, the amount of funding, and dissatisfaction by State agencies over Federal regulations. Disillusioned by their concerns, both its proponents and opponents sought to amend the act.

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[14] F. J. Munger and R. F. Fenno, *National Policies and Federal Aid to Education* (Syracuse, N.Y.: Syracuse University Press, 1962); and J. L. Jundquist, op. cit.

[15] J. S. Berke and M. Kirst, *Federal Aid to Education: Who Benefits? Who Governs?* (Lexington, Mass.: D.C. Heath, 1972); F. M. Wirt and M. Kirst, *The Political Web of American Schools* (Boston, Mass.: Little, Brown & Co., 1972); F. M. Wirt and M. Kirst, *The Political and Social Foundations of Education* (Berkeley, Calif.: McCutchan Publishing Corp., 1972); and M. Kirst, "The Growth of Federal Influence in Education," in *Uses of the Sociology of Education*, C. Wayne Gordon (ed.) (The 73rd Yearbook of the National Society for the Study of Education, Part II) (Chicago: National Society for the Study of Education, 1974).

The total funds allocated to federally sponsored programs appear to be a sizable Federal investment in education ($8.8 billion in fiscal year 1978-79). But when viewed as a proportion of a State and local education budget, the Federal investment seems less significant. Federal funds have accounted for between 6 and 9 percent of State and local education budgets. Monetarily, then, this influence is relatively small.

Concerns by local and State officials over regulations designed to enforce provisions of the act have been extensive and numerous. Many of the regulations resulted from the original complexity of ESEA and from the need to target funds to discreet groups with special needs. Concerns and fears relating to Federal control over State and local education programs have not been realized. This has resulted from a combination of factors: the small investment in each program per community or per State by the Federal Government; staffing constraints at the Federal level, making "control" or extensive influence difficult; provisions written into the act prohibiting such authority; and, finally, State pressures against increased Federal influence.[16]

With the passage of education legislation in the 1960's and 1970's, the role of the Federal Government in education is, generally speaking, fivefold:

- Promotion of equal oppportunity as exemplified by ESEA, the Education Amendments of 1972, by grants and legislation for the handicapped, by desegregation efforts and bilingual decisions, and by others.
- Innovation and stimulation of education reform through research grants, teacher training, vocational education, reading improvement programs, and others.
- Provision of grants in support of educational research—the results of which could have broad applications in the Nation's schools.
- Promotion of educational preparation for employment, which can be traced to the Smith-Hughes Act of 1917. "The school's potential contribution to economic productivity was thus the first, and for a long time, the only expressed national interest in education."[17]
- Provision of limited funding targeting specific needs areas such as planning grants for management purposes on the State level, equalization reforms for State finance mechanisms, instructional equipment, and others.

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[16] M. Timpane (ed.), *The Federal Interest in Financing Schooling* (Cambridge, Mass.: Ballinger, 1974).

[17] Ibid.

The Courts and Education

As ESEA moved into the implementation phase, the educational debate moved into the judicial arena. The courts have addressed numerous education-related issues ranging from questions of student and teacher behavior to those of access to educational resources. These issues, traditionally addressed on the State and local level and more recently by Congress, have now become the work of the courts.

The schools have been caught up in the complex multiracial and ethnic societal problems of our times which involve great moral and political issues and which the legislative and executive branches of the government seem unwilling or unable to resolve. Although lawyers and law courts in general possess no special expertise in educational matters, they have nonetheless been called upon to lend a helping hand with these school problems, which are fundamentally a function of social change taking place in society over the past twenty years or more.[18]

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[18] J. Hogan, "Law, Society and the Schools," in *Uses of the Sociology of Education*, C. W. Gordon (ed.) (The 73rd Yearbook of Education, Part III) (Chicago: National Society for the Study of Education, 1974), p. 411.

The involvement of the courts in educational issues can, from a historical perspective, be divided into three phases. Prior to 1850, educational issues were considered by the judiciary as State and local matters with no court role. Between 1850 and 1950, the court maintained this stance. When many parents brought cases before the courts, the courts usually found that the 10th amendment declared education to be a State and local responsibility. The third stage, from 1950 to present, can be characterized as one of active judicial involvement in educational issues, particularly by the Supreme Court. During this period the courts were involved in all aspects of education, including administration, program development, and organization.

Desegregation.—Court involvement in educational matters began in 1954 with the landmark *Brown* v. *the Topeka Board of Education* decision. In the *Brown* case, the courts declared that schools that were deliberately segregating children on the basis of race were inherently unequal and thus were creating a situation that was unacceptable. "Separate but equal" was found to constitute a violation of the 14th amendment. This decision not only paved the way for desegregating schools in the South; it also opened up many other legal issues that are still being contested today. Nevertheless, the *Brown* decision did not truly become effective until the passage of the Civil Rights Act of 1964. Since the *Brown* case, courts have addressed such questions as those relating to church and state relations in the schools, to free speech, to the financing of education, to curriculum, and to student and teacher rights. Most of these cases focused on the first and 14th amendments. In general, the courts held that State and local governments should retain their authority over most educational matters.

Religion in the Schools.—In one major area of court involvement, church and state relations, the first and the 10th amendments have been used to balance competing constitutional questions. The courts have drawn a very fine line in their decisions regarding religious issues in education, and no clear pattern has emerged. The courts have ruled, for example, that there can be no direct aid to parochial schools, yet the States may lend textbooks to these institutions. In addition, parents can be reimbursed for transportation costs to parochial schools. With regard to principles of free speech, State laws requiring prayers in public schools and those preventing the teaching of the Darwinian theory of evolution in public schools have been found to be unconstitutional. Similarly, the courts have ruled that enforced pledging of allegiance or saluting the flag is in violation of the first amendment. In general, questions or issues that impose specific standards of conduct on students and teachers have been found to be unconstitutional.[19]

Parental Right to Educate.—Another area of limited court involvement has been the question of parental right to educate children in the home. Since questions arise from State to State as to the legality of home instruction, most parents do not openly acknowledge removing their children from the public school system for fear of reprisal from State agencies and ensuing court actions. It is estimated that there are 1 million parents engaging in home instruction. Thirty-two States now have legal provisions for home instruction, but again, these vary from State to State.

State and Local Funding Mechanisms.—Nearly one-third of all State and local expenditures are education related. With increasing pressures from the courts, from parents, from interest groups, and from the Federal Government to provide educational services, local districts are reexamining the means by which their programs are funded. School finance reform comes at a time of declining enrollment in many parts of the country and in a climate of reduced funding both on the State level (taxpayer revolts) and nationally, with budget reductions and challenges to the traditional means of funding—property taxes. A brief historical examination of funding mechanisms is merited because funding reforms will affect the ability of State and local districts to introduce information technologies into their schools.

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[19] Ibid.

The educational structure in most Northeastern States largely followed that of Massachusetts, in which towns were divided into districts that retained responsibility over educational matters including school finance—a practice that continued through the 18th century. In the early part of that century, Northern States began to exercise minimal control over inspection, curriculum, and similar institutional concerns. Increasing State involvement gave rise to the growth of State boards of education and, by the 19th century, the State exercised a good deal of control over educational matters through these boards. Throughout this time of expanded State jurisdiction, financial control remained a local responsibility.

The South, unlike the North, generally relied heavily on the States for both administrative tasks and financial support. This practice became widespread in the post-Civil War period, at which time a system of State financing of local districts was firmly established.

In the 20th century with the rise of industrialization and increased urbanization, localities turned more and more to the States for financial relief from the growing educational burden. It became evident at this time, as in many of the cases before the courts today, that there were wide discrepancies among districts on the amount of funds expended per child and per school. Some States did increase the funding allocations, though the impact was minimal and inequities remained.

By the 1960's, spending on elementary and secondary education was increasing at an annual rate of 10 percent, with enrollments growing by about 30 percent. In the 1970's with the rapid decline in enrollments, court challenges to the finance systems, and pressures from taxpayers, made school finance reform become a topic of debate in most State legislatures. Every State established commissions to examine the financing systems, and 18 passed legislation to remedy recognized inequities. Thus, the early 1970's was a period of heightened activity within the State legislatures concerning school finance reform. The latter part of the decade was a time of court interpretations of State laws as well as a time of interpreting new legislative actions.[20]

More recently, cases before the courts have focused on financing mechanisms employed by State and local governments for school districts. A series of cases have challenged the means by which local communities finance educational services, specifically property taxes. In 1971, the California Supreme Court struck down the State's system of financing education in the *Serrano* decision. The court found that the California system, because it discriminated against those living in property-poor districts, violated the equal protection clause of both the U.S. and California constitutions. In the *Rodriguez* v. *San Antonio Independent School District*, the U.S. Supreme Court rejected claims similar to those in the *Serrano* decision. In this instance, the court declared that, although there was inequity in the financing system in this Texas district, there was "the absence of any evidence that the financing system discriminates against any definable category of poor people or that it results in the absolute deprivation of education—the disadvantaged class is not susceptible of identification in traditional terms."[21]

Although the *Rodriguez* decision found that Texas' financing system was not unconstitutional, numerous cases before State courts continue to challenge State financing systems. In early 1981, 31 cases relating to *Serrano* issues were before the courts. The latest challenge, in New York State, found that that State's financing system was, "constitutionally deficient" in that it discriminated against children living in poor districts. Reliance on property taxes to raise educational revenues has lead to wide disparities in New York State. In the decision it was noted that, although education is not a Federal constitutional right, nor "such a fundamental State constitutional right as to envoke special constitutional protection, it is an interest of great State importance." Therefore, the equal protection requirement of the State constitution was invoked.

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[20] W. N. Grubb and S. Michelson, *States and Schools* (Lexington, Mass.: D. C. Heath, 1974).

[21] D. L. Kirp and M. G. Yudoff, *Educational Policy and the Law* (Berkeley, Calif.: McCurhan Publishing Corp., 1974), p. 587.

Federal Role in Museums

Federal support of museums is very recent and began with the creation of the National Endowments for the Arts and for the Humanities in 1965. The first program grants to museums were initiated in 1971 by the National Endowment for the Arts. The endowments provide grants for projects or specific endeavors. These funds may not be used for operational purposes to support general programs.

Federal support for the general operation of museums became available with the establishment of the Institute for Museum Services (IMS) in 1977. IMS, now within the Department of Health and Human Services, is designed to provide funds for rent, heat, lights, and the like to museums. This institute has no funding support in the current fiscal year. Another avenue for support of museum programs, again in a limited fashion, is through the National Science Foundation, which allocates funds to science museums, though the educational division funding has been curtailed.

One of the most crucial forms of Federal support, albeit indirect, is through gifts or donations to museums by individuals or corporations. Tax deductions, made possible through legislation, provide important incentives for donors.

Federal Role in Libraries

Libraries began to receive significant amounts of Federal aid only in the 1960's, when the Federal Government undertook a major effort to provide services and opportunities to the disadvantaged members of society. The major pieces of legislation that provide for assistance to libraries include the following.[22]

- The Library Services and Construction Act (LSCA) of 1964. Replacing the Library Services Act, this legislation provided a major impetus to the use of and interest in libraries. Continually reauthorized since then, it has served as one of the major channels through which the Federal Government has provided assistance to libraries.
- The Elementary and Secondary Education Act of 1965. Title II of this act authorized $100 million to be spent by States for school library resources. As a result, libraries were established in the elementary schools in many hundreds of cities and rural areas.
- The Higher Education Act of 1965. Title I of this act specified that 22 percent of the funds provided be allocated for public community colleges and technical institutes. Title II provided Federal assistance to college libraries. It authorized funds not only for the purchase of books, periodicals, and other library materials, but also for library training programs and for R&D for new ways to program, process, store, and distribute information.
- The Federal Government has also provided continued support to the Nation's research libraries—the Library of Congress, the National Library of Medicine, and the National Library of Agriculture.

The momentum that developed in the 1960's in support of libraries began to wane in the 1970's. The Nixon administration eliminated from its budget appropriations for all non-Federal libraries. The Carter budget for 1980 also reduced library funding. It called for a $388 million reduction in Federal aid to schools and libraries; it eliminated funds for college library resources, training, and demonstrations; and it significantly cut back funds for library services, interlibrary cooperation, and library materials. Similarly, the Reagan administration's proposals for libraries also call for greatly reduced funding. Funding, for example, under ESEA has been incorporated into block grants under the Education Consolidation and Improvement Program.

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[22] V. H. Matthews, *Libraries for Today and Tomorrow* (Garden City, N.Y.: Doubleday & Co., 1976.)

Notwithstanding these significant reductions in the subsidies for libraries, the Federal Government continues to provide substantial support, most of it channeled through State agencies. In fiscal year 1982, for example, total Federal appropriations for library services under LSCA was $71,520,000, total appropriations for libraries and instructional and total Federal appropriations under title II of the Higher Education Act were $8,568,000.

Effect of Federal Telecommunication Regulation and Legislation on Education

Regulations, statutes, and ordinances at all three governmental levels have shaped the growth and structure of the telecommunication industry and have significantly affected the use of telecommunication technology by educators. A number of regulations have attempted to foster the application of communication services to education directly (e.g., Federal Communication Commission (FCC) rules governing instructional fixed television systems).

However, while the focus and legislative intent of some regulations have been on the provision of educational services, others have focused exclusively on telecommunication per se, disregarding their potential effects on education. These latter regulations, although necessary to effect the provision of telecommunication services, have inadvertently affected the use of modern telecommunication technology for educational purposes by forcing educators to compete for its use with wealthier and more politically powerful interests. This situation has had a detrimental effect on education by preventing and inhibiting educators from realizing the benefits of this technology. It has become increasingly apparent that telecommunication regulators must recognize the impacts of their decisions on education and must begin to take into account the interests and needs of education in formulating national telecommunication policy.

Governmental Control of Telecommunication

Telecommunication is regulated at all three governmental levels. On the local level, programing options are weighed and decisions are made. For example, Instructional Television Fixed Service (ITFS) licenses are, by their very nature, confined to local delivery of information. Once FCC has granted an ITFS application, the local operator/licensee controls its programing input and the extent of its output. States have the authority to regulate cable franchising by local municipalities and to set up rate structures for the public utilities. Most of the regulation of telecommunication, however, takes place at the Federal level, and it is this level which is of primary interest here.

Governmental Control of Education

Education is largely controlled at the local and State levels. At the local level, it is carried out primarily by local school boards; while accreditation and licensure functions are performed at the State level. The State's exclusive power over education derives from the

Reserved Powers Clause of the 10th amendment.[23] Thus, Federal laws relating to education usually include a reference to the primacy of the States.[24] For example, the *General Education Provisions Act* states that: "No provision of any applicable program shall be construed to authorize any department, agency, officer or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution . . . ."[25]

The traditional role of the States in controlling education may, where telecommunication technology is concerned, run into direct conflict with Federal laws and Federal policy. Specifically, State educational policies concerning telecommunication may conflict with the interstate commerce powers of the Federal Government, the express provisions of the Communications Act, and the general principles of the first amendment.[26] For example, the power of the States to control education is often exercised through the process of licensure of educational institutions and services. However, licensure requirements vary widely from State to State. Thus, an institution that seeks to offer programs, such as telecourses, on a regional or national basis must deal with several different licensure statutes. The question then arises as to whether the State receiving the service has jurisdiction to impose its licensure requirements on the offering institution, especially where the institution has no other contacts within the State.

The more fundamental issue, however, is whether these State licensure requirements operate to circumscribe various available services and thus impose an undue burden on interstate commerce, in violation of the Commerce Clause of the constitution.[27] [28] In other words, can the several States constitutionally control the delivery of multi-State educational services flowing into their borders or are such services covered under this clause subject to Federal control? The issue has not yet been resolved, but it is clear that in the near future it will demand greater attention and will require resolution by the courts.[29] In the meantime, State licensing authorities are free to adopt discriminatory and protectionist regulations that have a potential chilling or inhibitory effect on the provision and delivery of educational programs and services.

The Federal Communication Commission and Educational Telecommunication Services

Various Federal rules and regulations governing telecommunication also affect educational programs and services. Under the 1934 Communications Act, FCC has jurisdiction to allocate the broadcast spectrum among communications services. In the past, the commission has made several policy decisions directly intended to promote educational access to the broadcast spectrum. The clearest example was the commission's reservation of 242 channels in the very high frequency (VHF) and ultrahigh frequency (UHF) bands for educational use. In 1938, 1945, and 1952, respectively, the commission announced that several radio and television channels were being reserved for the use of nonprofit educational organizations advancing an educational purpose. These decisions presaged the beginning of educational or instructional television and directly provided for community educational programing.

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[23] The powers not delegated to the United States nor prohibited by the Constitution to the States, are reserved to the States respectively, to the People.

[24] M. B. Goldstein, "State Licensure of Instructional Telecommunications: An Overview of a Constitutional Problem," *Telescan* 1(3):3, January/February 1982.

[25] *General Education Provision Act*, sec. 432, 20 U.S.C. sec. 1232a).

[26] M. B. Goldstein, *A Survey of Key Policy Issues Affecting Higher Education and the Adult Learner*, discussion draft prepared for The Ace Commission on Higher Education and the Adult Learner, October 1981, p. 39.

[27] The Commerce Clause gives Congress the power to regulate interstate commerce. U.S. Constitution, art. I, sec. 8, clause 3.

[28] M. B. Goldstein, "Federal Policy Issues Affecting Instructional Television at the Postsecondary Level," *Adult Learning and Public Broadcasting*, report of a project conducted by the American Association of Community and Junior Colleges with support from the Fund for the Improvement of Postsecondary Education (FIPSE), 1980, p. 45.

[29] This argument was recently raised in an action by Nova University, to prevent the State of North Carolina from regulating the offering of education services in that State when the degree conferred was authorized by the school's domicile State, Florida. While the case was ultimately decided on narrow statutory grounds, the issue of State v. Federal powers was strongly enunciated in the arguments put forth by both sides. *Nova University* v. *University of North Carolina*, No. 110A81, N.C., Mar. 3, 1982.

The commission's original intent in setting aside these channels was to promote noncommercial educational broadcasting. FCC took a broad view of such broadcasting, and no programing requirements were assigned to its instructional and cultural components. It has been claimed that the failure to define the term **educational broadcasting** more narrowly had, in fact, the effect of diminishing the amount of instructional programing, which resulted in a public broadcasting system that serves a wider audience.[30] In the absence of a narrowly drafted set of regulations governing educational broadcasting, market forces took over and influenced decisions on programing content by licensees and broadcasters. The programing on the channels originally reserved for educational broadcasting became predominantly cultural in content.

Instructional Television Fixed Services

The regulation of ITFS is a further illustration of the effect of regulation on the educational use of telecommunication. ITFS is a point-to-point communication system that can transmit up to four channels of programing at one time to predetermined reception points located from 5 to 20 miles away. Therefore, it is a method of transmitting television signals directly to the classroom.

ITFS was established in 1963 when FCC opened 31 channels in the 2500- to 2690-MHz frequency range for this private distribution system. It was intended to satisfy the need for a more economical and efficient means of distributing high quality learning materials to the classroom. In the 1970's, FCC issued rules and regulations that provided for the licensing of 28 of the 31 available channels to educational institutions. The remaining three channels were to be assigned to municipal or State governments for operation of a similar service, Operational Fixed Service (OFS).[31]

Soon after ITFS was established, FCC received many construction permit requests for the use of its assigned channels. However, the cost of the components necessary to operate an ITFS system, (transmitters, receivers, studio equipment, down converters, etc.), prevented most educational institutions from utilizing this technology. ITFS was thus installed and used predominantly by larger universities capable of affording it.[32] Once installed, the system was economical to operate. Currently, ITFS is being used to provide a variety of educational services, including adult and professional continuing education courses. Some universities, such as the University of Southern California, use an ITFS system to transmit graduate engineering courses to nearby businesses and firms with staff engineers. The future of this system and its use as an educational tool is uncertain.

In 1980, FCC began proceedings to reallocate the 31 channels in the 2500- to 2690-MHz frequency range, the assumption being that educators were not taking full advantage of the channels allocated to ITFS.[33] Faced with an increasing demand and a growing number of applicants for Multipoint Distribution Services (MDS) and Private Operational Fixed Microwave Services (POFMS), FCC proposed to redistribute these channels by allocating 10 each to MDS and POFMS, leaving ITFS with the remaining 11.[34] As satellite distribution of programing made MDS more profitable and as the market demand for MDS grew and developed, FCC proposed to offer MDS operators use of part of the spectrum allocated to ITFS. Similarly, as business and industry found new uses for POFMS, demand for frequencies to operate this service has grown. Thus, FCC proposed to reduce the number of ITFS channels to make room for MDS and POFMS systems.

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[30] S. A. Shorenstein, "Pulling the Plug on Instructional TV," *Change*, vol. 10, November 1978, p. 37.

[31] OFS is functionally equivalent to ITFS. It is a short-range private distribution service intended for governmental as opposed to instructional use.

[32] As of Jan. 1, 1981, there were 180 ITFS licensees in the United States, *Television Factbook*, stations volume, 1981-82 ed. No. 50.

[33] General docket Nos. 80-112; 80-113; 80-116.

[34] MDS is a common carrier service, delivering pay-TV programing from a central transmitter to several line-of-sight reception points.

Here again, FCC had created by direct regulation a system primarily for offering educational programing. Yet, because of high installation costs, along with budget cuts, ITFS has not been used by most educational institutions. Although FCC has not yet acted on this proposal, clearly a reduction in ITFS channels will have an effect on cities like New York and Los Angeles where ITFS is widely used. While it is possible that such large metropolitan areas, which have as many as 25 operational ITFS systems, may have to curtail their use and reduce the number of educational services offered, it is more likely that FCC will "grandfather" (allow them to continue under the new system) active channels as long as the present licensees retain their control. Only assigned but inactive ITFS channels would be reassigned for commercial spectrum use. A further consequence of the proposed cutback in ITFS channels is that it may affect the recent Public Broadcasting Service (PBS) application for ITFS facilities.

The Public Broadcasting Service

PBS and its member public television stations have applied for ITFS channels to set up the National Narrowcast Service to extend their distribution of instructional, educational, and cultural programing to meet specialized, educational needs. The system is designed to reach those who live where educational programing is not readily available and to create a local means for expanding the educational services offered by PBS stations. If FCC decides to reallocate the ITFS frequencies, this proposed service will be in jeopardy. With fewer ITFS channels available, PBS will have to compete for channels with other educational users. While the FCC proposal will, if adopted, increase the number of channels available for commercial MDS and POFMS systems, it will also limit the availability of educational services to the community through ITFS systems. In effect, another educational resource would be reduced and replaced by services unlikely to be available for educational programing.

Low-Power Television and Direct Broadcast Satellites

While low-power television (LPTV) and direct broadcast satellite (DBS) systems may become available for distributing educational programing, they are not equivalent substitutes for ITFS. LPTV applications will be granted on the basis of an available broadcast spectrum, and educational institutions wishing to apply for such frequencies will have to compete with other users for a frequency allocation. In other words, allocation by FCC will occur entirely apart from the needs of the educational community. In addition, although DBS service has the potential to reach nationwide audiences, it is unclear whether DBS applicants will, in fact, transmit educational programing to the public or whether educational institutions will be able to afford satellite time. The answer to these uncertainties will be known in time if rules and regulations are adopted to govern both LPTV and DBS systems. Given the present emphasis on deregulation, it is unclear whether LPTV and DBS will be regulated to provide educational services.

Cable Television

Another area where telecommunication regulation has affected education is illustrated by cable television requirements. FCC rules originally required that all cable systems serving more than 3,500 households provide opportunities for "educational access with no cost for use of the system."[35] At present, only a few universities (e.g., Purdue and Oregon State University) use this resource. Furthermore, specialized, educational programing generally comprises a very small part of cablecasters' offerings. The regulation of telecommunication via cable is in transition.

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[35] These requirements have been overturned by the courts. See *Midwest Video Corp.* v. *FCC*, 571 F. 2d 1025, 41 R.R. 2d 659 (8th Cir. 1978) (Midwest Video II), cert. granted, 47 U.S.L.W. 3187 (No. 77-1575). However they would be reinstated to some extent by the passage of S. 2172.

Telecommunication Legislation and Educational Services

The Senate Commerce Committee has recently introduced a bill to move primary jurisdiction over cable regulation from the cities and States to FCC.[36] The bill also requires that cable systems with more than 20 channels dedicate 10 percent of such channels for use by public, educational, and governmental programers and 10 percent to leased channel programers, all on a first-come, first-served, nondiscriminatory basis.[37] This bill represents one of many congressional efforts to revise telecommunication regulations and set national telecommunication policy. Although this legislation explicitly provides for educational programing, other bills, such as those dealing with revision of the 1934 Communications Act, often do not address educational interests. Such congressional consideration is necessary to ensure the low-cost availability of telecommunication services to educators in both the public and private sector.[38]

As with FCC regulation, telecommunication legislation may have both a direct and indirect effect on the means by which educational services are provided and on the ability of educators to utilize telecommunication for disseminating educational materials. Legislation can affect the cost of interconnections, the means of delivering services, and the nature of educational programing.

Congress has directly influenced the manner and scope by which educational services are provided both in approving appropriations for the Corporation for Public Broadcasting (CPB) and by enacting legislation like the Public Telecommunications Financing Act.[39] Congress has also proposed legislation which, although dealing with telecommunication, could indirectly set a precedent regarding the provision of educational services. For example, a bill introduced by the House Subcommittee on Telecommunications, Consumer Protection, and Finance, which revises and updates title II of the 1934 Communications Act governing the provision of telephone and telecommunication services, may have important implications in the educational arena.[40] Access provisions under the proposed legislation may affect the costs of interconnections for home computers. This, in turn, could affect the demand for such terminals. Similarly, issues of maintenance, ownership, and technical grades of lines and wiring may affect the quality of data communication and ultimately the supply of information for educational purposes. These issues need to be considered by legislators in their efforts both to rewrite the 1934 Communications Act and to set national telecommunication policy.

As the foregoing discussion has shown, telecommunication regulation often indirectly discriminates against educational services by overlooking the stake educators and institutions have in telecommunication resources. An issue entirely separate from that of telecommunication legislation and its effect on education, however, is the issue of Federal regulation of education and its effect on the use of telecommunication. Although warranting more consideration, it can only be dealt with briefly here.

The clearest example of how educational regulations can have a chilling affect on the educational use of telecommunication is a Veterans Administration rule restricting and prohibiting reimbursement and educational benefits to veterans for curricula that use courses taught via television and radio. While the rationale behind this regulation may have been to prevent veterans from claiming credit for sham courses, it clearly discriminates against technology-based delivery systems and hence can be deemed overbroad. Less restrictive alternatives must be found to meet the Veterans Administration's proper concern without compromising and discriminating against telecommunication technology.[41] As with telecommunication policy, the interests of educators must be weighed and considered in drafting Federal regulations.

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[36] "Where Things Stand," *Broadcasting*, Apr. 5, 1982, p. 26.

[37] U.S. Congress, Senate, *A Bill To Amend the Communications Act of 1934*, S. 2172, 97th Cong., 2d sess., 1982.

[38] A. B. Shostak, "The Coming Systems Break: Technology and Schools of the Future," *Phi Delta Kappan*, vol. 62, January 1981, p. 359.

[39] U.S. Congress, *Public Telecommunications Financing Act*, Public Telecommunications Financing Act, Public Law 95-567, 95th Cong., Nov. 2, 1978.

[40] U.S. Congress, House, *A Bill To Amend the Communications Act of 1934 to Revise Provisions of the Act Relating to Telecommunications*, H.R. 5158, 97th Cong., 1st sess., 1981.

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[41] Goldstein, op. cit., 1980, p. 42.

The Protection of Information Software: An Overview

In recent years, the software industry has been plagued by an everincreasing incidence of piracy.[42] [43] As software costs have risen, informal duplication of programs has increased and has held down revenues for software publishers.[44] Similarly, piracy via illegal duplication and distribution has diminished incentives for software producers to further development of novel and innovative software packages, particularly for educational use. Although technological solutions are being devised to prevent piracy, various legal methods for protecting computer software from illicit misappropriation are the focus here.

Given the fact that for the present, at least, piracy does and will occur, the question to be resolved is how to protect the software producer or proprietor from infringement of his creative property rights. Such protection is necessary to ensure that adequate incentives exist for development of innovative software, to protect the considerable investments in its development, and to preserve legal means for public access to creative works.

There are five currently legal methods that can be used to protect computer software: trade secret protection, trademarks, patents, the doctrine of unfair competition, and copyrights.[45] None of these, however, provides a well-defined, reliable form of protection for novel developments in software.[46] The law regarding software protection in each case is hazy and complicated and still in the early stages of development. Thus, it may be necessary to use several methods simultaneously, with or without technological protection, to achieve maximum legal protection for certain software. While copyrights and trade secrets are the most widely used and advocated forms of protection, each of the five methods can afford some degree of security against unauthorized reproduction of costly and innovative software.

Types of Software

All computer software has three basic components. These are the supporting documentation, including manuals and flow charts; the algorithm or process, i.e., the underlying ideas or information implemented in the software; and the program or data base itself.

The program itself is embodied either in human readable form, such as listings, or in computer readable form, such as magnetic tapes, disks, or paper punch cards. These distinctions are important, because the utility of the various methods of legal protection may differ depending on the type of software component and the formal representation involved in a particular case.

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[42] The term software is meant to include any programs and data bases designed to be used on computers, video disks, cable, etc.

[43] D. U. Gagliardi, "Software: What Is It," *APLA Quarterly Journal* 8(3), 1980, p. 239.

[44] When programs are copied without permission, publishers do not receive royalties for their use and their profits are thereby reduced. See "Trends in Personal Computer Software Publishing," A Research Memorandum, *LINK*, NRM, vol. 2, No. 10, August 1981.

[45] It should be noted that there is a diversity of views as to what forms of legal protection are currently available and what forms should be available in the future for software products. Not all legal scholars agree that the five methods surveyed here are available or should be used for protection.

[46] H. Levine and A. E. Hall, "Computer Software Protection and Licensing," a paper presented at the Second Annual Talmis Conference, Chicago, Feb. 28, 1982.

In addition to the three software components, computer programs can be broken down into three formats or formal representations: the source code, the linkable formats, and the object code.

The source code, or "the code at its source," is a computer program written in a high-level (computer) language. This representation is the easiest to read and comprehend and hence to pirate, modify, and expand. The linkable format results from the processing of the source code by the computer's compiler or program converter. At such a level, it is more difficult to reconstruct and, hence, to appropriate. The object code results from loading the linkable format into the computer in a form that it can execute. In this format, the program's underlying concepts are the most difficult to assimilate, comprehend, and appropriate.

Legal Protection for Software

Trade Secret Protection

Trade secrets are defined as formulas, processes, mechanisms, compounds, or compilations of data not patented but known only by certain individuals using them in business to obtain a commercial advantage.[47] The classic and most widely cited example of a trade secret is the Coca-Cola formula, which is known only to certain select Coca-Cola personnel and has never been patented.[48]

For a trade secret to exist and be enforced, several requirements must be met. The first is secrecy; a bona fide secret must exist and must be contained within the business of a particular enterprise. Thus, those who are privy to the secret must be under a duty not to disclose it. This situation is generally achieved by a confidential disclosure agreement or contract between the proprietor or software marketer and his employees, contractors, licensees, or leasees. The contract may require those with access to the software to take actions to limit its proliferation. The second requirement for trade secrets to exist is novelty—i.e., where the subject matter is unknown to the general public and the trade.[49]

Beyond these two formal requirements for trade secrecy, the courts have placed some reliance on economic criteria in determining whether a protectable trade secret exists. The amount of money or labor expended in developing information and the value of the information itself are factors which courts might consider in making this determination.

It is well established that computer programs and certain program materials are protectable as trade secrets through civil and criminal enforcement actions. However, the boundaries of trade secret protection for software are unclear. Some courts have protected algorithms along with the computer programs, while others have declined to extend protection to "general information."[50] The nature of the software, the circumstances of the taking, and the intent of the taker can each influence a court's determination regarding trade secret protection.

In deciding whether to utilize trade secret protection for certain software, a proprietor or marketer considers the following drawbacks. First, trade secrecy can be easily lost. If a secret becomes widely disseminated, the software protected may become part of the public domain and thus no longer eligible for trade secret protection. Thus, trade secrecy may be difficult to maintain where public sales or large-scale marketing of software is contemplated. Trade secrets can also be lost by carelessness, by intentional or negligent breach of contract, or by discovery and disclosure by competitors, e.g., reverse engineering and subsequent disclosure. The courts are split as to whether trade secret protection is lost where software is appropriated by memory. The majority rule is that trade secrecy does protect against appropriation by memory.[51] Similarly, there is some debate about whether trade secrecy is lost where a software proprietor registers his software for copyright protection. The issue here is whether such registration constitutes publication and hence destroys any legal claim under the trade secret method of protection.[52]

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[47] *Restatement of Torts,* SS 757, Comment (b), 1939.

[48] *LINK,* op. cit., p. 18.

[49] Novelty for purposes of trade secret law is a relative concept unlike novelty for purposes of patent protection. In the latter case, novelty is absolute; D. Bender, "Trade Secret Software Protection," *APLA Quarterly Journal,* vol. v, No. 1, 1977, p. 51. It should be noted that novelty is not required by all States. See R. Milgrim, *Trade Secrets,* SS 2.03, 2.08(2), 1979.

[50] R. Smith and E. R. Yoches, "Legal Protection of Software Via Trade Secrets," *APLA Quarterly Journal,* vol. 8, No. 3, 1980, p. 240-241.

In addition, trade secret protection, like the law of contracts and unlike copyrights or patents, is controlled by State statute or common law, as distinguished from Federal statutory law. Thus, protection for trade secrets differs from jurisdiction to jurisdiction. In order to maximize his protection, a manufacturer or licensor may wish to seek an additional mode of protection, such as copyright, to ensure uniform legal treatment of his software. Trade secret protection alone, however, can provide a fairly reliable and economic means of shielding software innovation.

Trademark Protection

Trademarks generally include "any word, name, symbol, or device or any combination thereof adopted and used by a manufacturer or merchant to identify his goods and distinguish them from those manufactured or sold by others."[53] While they are used extensively to protect product names, they have been used only in a relatively minor manner to protect computer software. The reason for this is that in the past computer software has had a relatively short life, and thus there was no basis on which to build a proper trademark. The current trend of "longer life" computer programs may no longer sustain this reasoning.[54] In addition, trademarks do not directly protect the contents of the software from unauthorized use, appropriation, or duplication by another. However, trademarks can serve as a complement to other methods of protecting the concepts contained in computer programs. Computer program trademarks can protect important proprietary interests in software by preventing software competitors from using the same or similar marks on their programs.

The U.S. Patent and Trademark Office has recognized for some time that computer programs are "goods" within the purview of the Trademark Statute.[55] Thus, a trademark on an item of software represents and is identified by the public with the goodwill and reputation of the business that produced it. If the manufacturer's reputation is good, consumers may tend to buy software based on the strength of the mark, even though competing products may perform as well. Whether the strength of mark will be the sole criteria used by consumers in selecting software, or whether the capabilities of various programs will also be taken into account in making a selection, is an open question. In either case, though, consumers will probably place some reliance on the source of quality control identified through the trademark.[56] In this manner, trademarks provide a relatively inexpensive and simple means to protect indirectly computer programs.

Patent Protection

At present, there is much uncertainty about the applicability of title 35 of the United States Code (patents) to computer software. The case law is inconsistent and confusing, and no clear-cut consensus has been reached. In addition, to the extent that some patent protection for software is available, it would apply only to protect the programmable process embodied in computer programs.[57] Thus, patent protection for software is often difficult to obtain except in conjunction with a patentable piece of computer hardware. Given the unpredictable nature of software patent law and the relatively high cost of securing patent protection, a software owner may therefore wish to seek other available methods of legal protection for his works. Once clarified, though, patent protection for certain software may prove to be superior to other legal methods.

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[51] Turner, *The Law of Trade Secrets* 169, 171, 1962.

[52] In a recent case, the court held that this was a question of fact and not a question of law. *Warrington Associates, Inc.* v. *Real-Time Engineering Associates, Inc.*, 522 F. Supp. 367 (N.D. Ill., 1981).

[53] *The Lanham Act of 1946,* 15 U.S.C. SS 1127.

[54] T. G. White, "Trademark Protection of Computer Software," *APLA Quarterly Journal,* vol. 8, No. 3, 1980, p. 281.

[55] *The Lanham Act,* 15 U.S.C. SS 1051 et seq.

[56] White, op. cit., p. 280. In addition, although service marks could also be included here, they are beyond the scope of this brief overview and hence excluded from the discussion of trademarks.

[57] Bender, op. cit., p. 67. See also *Diamond* v. *Diehr* and *Diamond* v. *Bradley,* footnote 15.

There are several reasons why patent protection may be preferable to other legal safeguards of software innovation. One is that patent protection is very broad in scope. A patent provides its owner with the exclusive right to the inventive work for 17 years. Thus, he has the right to exclude others from making, using, or selling that work. Infringement occurs when either the work is copied or it has been independently developed. Another reason is that patents protect the underlying ideas or concepts of a computer program, not merely the expression of a program, as copyrights do. Thus, while an adaption of a program for use in a different computer may not be a copyright violation, it could be found to be a patent infringement.

The issues concerning the patentability of software are twofold. The first problem is whether software is statutory or within the categories of innovations and discoveries which may be patentable. The law is that an invention is patentable if it consists of "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof."[58] Abstract ideas, laws of nature, and physical phenomena are excluded from patent protection.[59] The question is, do computer programs fall under any of the categories of patentable inventions? The answer is that they may, if patentable, fall into the categories of processes, machines, or manufactures.

Several recent cases have overturned the courts' previous reluctance to hold software patentable.[60] Thus, the court has held that a statutory claim does not become nonstatutory simply because it uses a mathematical formula, computer program, or digital computer.[61] Currently, the law seems to be that algorithms or methods of calculation in the abstract, like the laws of nature, are not statutory subject matter. However, claims reciting algorithms or formulas, or presumably computer programs that implement or apply those formulas in a structure or process (e.g., transforming an article from one state or thing to another), are statutory within the meaning of the patent law.[62]

If certain software is found to be statutory then it must also meet four conditions to be found patentable: novelty, utility, nonobviousness, and adequacy of disclosure.[63] Numerous programs should meet these requirements. However, many others may implement an obvious process in an obvious way and are valuable solely because of the man hours saved to achieve the result.[64] They would, thus, be ineligible for patent protection. The problem then lies in the definition of "obviousness." So far, there is no clear consensus about the appropriate standard or test to be applied to determine if a claim meets the nonobviousness condition. Judicial or legislative clarification is necessary before the patentability of certain software can be determined with any degree of certainty.

It should be noted that the patentability of computer programs may also depend on the subjective application of Patent Office guidelines by patent examiners, and ultimately on the manner in which patent applications are drafted. Future clarification of the boundaries of software and computer program protection, however, awaits the outcome of further litigation.

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[58] 35 U.S.C. SS 101.

[59] *Diamond* v. *Diehr,* 450 U.S. 175, 209 U.S.P.Q. 1, 7 (1981).

[60] Earlier landmark cases include: *Gottschalk* v. *Benson,* 409 U.S. 63, 175 U.S.P.Q. 673 (1972); *Dann* v. *Johnston,* 425 U.S. 219, 189 U.S.P.Q. 257 (1976); *Parker* v. *Flook,* 437 U.S. 584, 198 U.S.P.Q. 193 (1978). Two recent decisions indicating that patent protection may be available for computer software are: *Diamond* v. *Diehr,* 450 U.S. 175, 209 U.S.P.Q. 1 (1981); and *Diamond* v. *Bradley,* 450 U.S. 381, 209 U.S.P.Q. 97 (1981).

[61] *Diamond* v. *Diehr,* op. cit.

[62] Levine and Hall, op. cit., p. 19.

[63] 35 U.S.C. 101, 102, 103, 112 (1979).

[64] Bender, op. cit., p. 67-68.

Protection Under the Law of Unfair Competition

Original software (both source and object code), computer programs, and data bases may be protected by the law of unfair competition. Evolving from the landmark case of *International News Service (INS)* v. *Associated Press,*[65] the law protects the originator against misappropriation by competitors of his work product and his investment capital risks. The rationale for the doctrine lies in the equity court's philosophy of preventing and mitigating unjust enrichment. Until recently, however, the courts tended to limit the application of the unfair competition doctrine to the facts in the *INS* case. In one recent case, the courts stated that a valid, unfair competition claim had been advanced where, for commercial advantage, a competitor had misappropriated the benefits and property rights of and had exploited his business values.[66] Similarly, where reproductions of original recordings were pirated and marketed under a different label, another court upheld the plaintiff's unfair competition claim.[67]

While the doctrine has had an underlying effect in cases dealing with unauthorized appropriation of data bases, today it is becoming grounds for equitable relief on its own merits. Therefore, it may be possible to bring a valid cause of action based on the common law right against unfair competition where a competitor copies and sells another's software for profit. This method of software protection may be of benefit to proprietors who seek to protect both source and object codes. The law of unfair competition would most likely make no distinction between the two for purposes of protection. However, it should be borne in mind that unfair competition is a common law doctrine and thus may vary from State to State.

Copyright Protection

By far, the fastest growing legal mechanism of software protection is the copyright law. It is now well settled that copyright law is available as a method for protecting software and computer programs. The question to be resolved, however, is the scope of the protection to be accorded computer programs by this body of law.

The Copyright Act of 1976 protects original works of authorship fixed in any tangible medium of expression from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device.[68] Computer programs and data bases, to the extent that they incorporate authorship in the expression of original ideas as opposed to the ideas themselves, fall within the category of "literary works," and thus within the subject matter of copyright.[69] The actual processes or methods embodied in a computer program, however, are not within the scope of the copyright law.[70]

In 1980, the Computer Software Copyright Act was passed by Congress.[71] Incorporating the recommendations of the national Commission on New Technological Uses of Copyrighted Works, the act revised section 117 of the 1976 Copyright Act dealing with rights in conjunction with computers and information systems.[72] The new section 117 dispelled all doubts concerning the copyrightability of computer programs and made it clear that the reproduction or adaption of computer programs would constitute acts of infringement. The act also created an important exemption for the input or reproduction of computer programs from copies which are sold.

The courts have not reached agreement on the limits of computer software copyright protection. For example, there is still much debate as to whether object codes can be protected by copyright law. In order to be accorded the protection of the copyright laws, a computer program must be "an original work of authorship."[73] Clearly, if a programer is the "originator" of a source code, than he qualifies as an "author" within the meaning of the copyright law. However, the case law is still developing on whether this source code authorship is preserved in the object code. Since the object code can be viewed as being physically produced by a machine, the question arises as to whether the object code is an expression of authorship or merely a utilitarian work outside the scope of copyright protection. Only original expressions of authorship, "writings," are protected by copyright law. There is little doubt that source codes are writings within the purview of the copyright statute, but the status of object codes is not so clear.[74] [75]

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[65] *International News Service* v. *Associated Press,* 248 U.S. 215, 39 S. Ct. 68 (1918).

[66] *Data Cash Systems, Inc.* v. *JS&A Group, Inc.,* 480 F. Suppl. 1063 (N.D. Ill., 1979), aff'd on other grounds, 628 F. 2d 1038 (7th Cir. 1980).

[67] *A&M Records, Inc., et al.* v. *M. M. C. Distributing Corp., et al.,* 197 U.S.P.Q. 598 (Sixth Cir., CA) (1978).

[68] 17 U.S.C. SS 102(a).

[69] 17 U.S.C. SS 101(a). U.S. House of Representatives Report 94-1476, 94th Cong., 2d sess., p. 54.

[70] 17 U.S.C. SS 102(b).

[71] *Computer Software Copyright Act of 1980,* Dec. 12, 1980, Public Law 96-517, sec. 10.

[72] *Final Report of the National Commission on New Technological Uses of Copyrighted Works,* July 31, 1978.

Other issues associated with the copyrightability of computer software are preemption of trade secret protection and the meaning of "substantial similarity," (necessary for copyright infringement) in the computer context.[76] In addition, problems with computer software copyright protection arise because the act of copying is incidental to use of a computer program. In other words, computer input (i.e., of a program) constitutes the making of a copy and is thus a potential infringement of copyright. The 1980 amendment to section 117 of the Copyright Act remedied this problem by providing that it was not an infringement for an owner of a copy of a computer program "to make or authorize the making of another copy or adaption of that computer program," provided that the copy or adaption "is created as an essential step in the utilization of the computer program in conjunction with a machine."[77] It is important to note, however, that this exemption only applies to copies of computer programs that are sold. Thus, if a copyright owner chooses to make the program available only by lease or by license arrangement, copying is permitted only under the terms and conditions specified by the copyright owner. Otherwise, computer input can constitute infringement.

Another troublesome area concerns the copyrightability of video software. Copyright protects only the expression of original works of authorship, not the ideas, methodology, or processes embodied in the software or adopted by the programer. Thus, copyright law protects the audiovisual aspects of video software as a display, but does not protect the underlying "idea" itself. Protecting the expression of a game program may necessarily also protect the system or process embodied in the game program or video display, a result violating the principles of the copyright law.[78] Thus, manufacturers of video games may protect the visual display of their software by registering a videotape of their screens with the Copyright Office. While registration is not a condition of copyright protection, it is a formality related to the ability to sue for infringement. Manufacturers of videogames, however, cannot preempt others from manufacturing and distributing games utilizing the same inherent ideas (e.g., mazes and dot gobblers) regardless of how inextricably linked they are to the program's original expression. In those cases where an injunction has been sought against distribution of allegedly similar games, it is not clear whether the courts relied on the doctrine of unfair competition or on copyright law in granting the requested relief. Although the courts apparently applied copyright law in these cases, they may have been influenced by unfair competition principles.[79]

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[73] 17 U.S.C. SS 102(a).

[74] For illustration of this conflict see: *Data Cash Systems, Inc.* v. *JS&A Group Inc., et al.*, 480 F. Suppl. 1063 (N.D. Ill. 1979), aff'd on other grounds, 628 F. 2d 1038 (7th Cir. 1980); *Tandy Corp.* v. *Personal Microcomputers, Inc.*, 524 F. Suppl. 171 (N.D. CA 1981). And more generally, *Goldstein* v. *California*, 412 U.S. 546 (1973).

[75] D. T. Brooks and M. S. Keplinger, *Computer Programs and Data Bases: Perfecting, Protecting and Licensing Proprietary Rights After the 1980 Copyright Amendments*, Law & Business, Inc., Harcourt Brace Jovanovich Publishers (1981).

[76] Thus, would translation of a program from Fortran to Basic be an infringement? Or, how much retrieval of a work from the computer is necessary to constitute substantial similarity?

[77] 17 U.S.C. SS 117(1).

[78] Matthew Bender, *Nimmer on Copyrights*, sec. 2.18(J) and 8.08 (1980).

[79] See *Stern Electronics, Inc.* v. *Kaufman*, 213 U.S.P.Q. 75 (E.D. N.Y., 1981), aff'd __ F. 2d. __ (2d Cir., filed 1/20/82).

The most that can be said with certainty is that some aspects of computer software can be legally protected via copyright. Programs tangibly fixed in books, catalogs, and instruction manuals are subject matter of copyright. Programs fixed on cards or magnetic disks that can be perceived directly or otherwise communicated, e.g., by means of a computer print-out or terminal, are protectable under the copyright law.[80] Other software, including object codes, may or may not be within the purview of the copyright law. Future developments both in Congress and in the courts will hopefully resolve the issues relating to this body of law.

Another issue relating to audiovisual software is that of copyright and home recording. The U.S. Court of Appeals for the Ninth Circuit held in *Universal City Studios* v. *Sony Corp.* (the *Betamax* case) that home videotape recording of over-the-air copyrighted television programs violates the Federal copyright law.[81] While the Court's decision will be reviewed by the U.S. Supreme Court next term, the Ninth Circuit Court ruled that home video taping for private, noncommercial use was not a "fair use" under the 1976 Copyright Act.[82] Furthermore, the court held that manufacturers, retailers, distributors and advertising agents for video cassette recorders could be held "contributorily liable" for this infringement.

While the decision has raised considerable debate concerning the rights of program producers to control the use of their productions and the rights of consumers to utilize new home electronics, it may also have an impact on the educational community. Thus, the educational community, and more specifically Action for Children's Television (ACT), has requested congressional legislation designed to permit home recording of television programs for education use. They argue that home taping would permit children to watch educational programs broadcast while they are in school.

Although a legislative solution to the *Betamax* debate is being sought by many interested parties, educational groups are concerned both that the type of programing software currently being broadcast and the cost of video cassette recorders may change (with or without royalty assessments) as a result of the present controversy.[83] Thus, one major concern is that schools that now buy video cassette recorders and use videotaped programs in the classroom may no longer be able to afford them. Also, education groups speculate that advertisers may support fewer over-the-air educational programs as a result of advertisement deletion by video cassette recorder owners. Although these problems remain to be resolved by the legislature and the courts, it is clear that producers of educational program software will be affected by the present taping/copyright controversy. As with computer software, the law of copyright in relation to audiovisual software is uncertain and still developing.[84] However, as demonstrated by the *Betamax* case, copyright is a viable and reliable means of protecting both computer and audiovisual software.

Legal Protection: Issues and Educational Options

It is clear that all five legal mechanisms for safeguarding software offer some degree of protection against misappropriation and piracy. Each method of software protection has different remedies for discouraging piracy and punishing infringement. For example, injunctive relief is available with all five legal methods. However, destruction of infringing copies and continuing royalties are available only for copyright infringement. Similarly, treble, punitive, and statutory damages are available only for copyright, patent, and trademark infringement. In addition, even where monetary and injunctive relief is available, the type of infringement (e.g., copyright, trade secret), may influence the way a court applies these remedies.

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[80] Nicholas Prasinos, "Legal Protection of Software Via Copyright," *APLA Quarterly Journal*, vol. 8, No. 3, 1980, p. 257.

[81] *Universal City Studios* v. *Sony Corp.*, 659 F. 2d 963 (9th Cir. 1981). The Supreme Court has recently granted certiorari to review the decision of the Court of Appeals, Ninth Circuit.

[82] Fair use is codified in 17 U.S.C. SS 107.

[83] In fact, there are several pending pieces of legislation dealing with this issue: H.R. 4808 (10/21/81). These bills would exempt private home recording of TV programs from copyright laws, but would not preclude later legislation to establish a royalty fee assessed against recorders.

[84] On Oct. 14, 1981, Rep. Robert Kastenmeier (D-Wis.), Chair of the House Judiciary Committee on Courts, Civil Liberties, and the Administration of Justice, inserted guidelines for off-air taping of copyrighted works for educational use in the Congressional Record. These guidelines were the result of a negotiated agreement between education groups, the broadcast industry, copyright owners, and industry guilds and unions. The guidelines allow fair classroom use of videotaped TV programs within specific time limits without infringing the rights of copyright owners.

Each method of software protection also has its advantages and disadvantages and its legal uncertainties. Many of the still unresolved legal issues stem from the fact that the primary intent of intellectual property law protection of software is to reward and encourage software creation and innovation, not primarily to punish copyists.[85] Yet, as software innovation becomes more costly and piracy more rampant, software manufacturers seek solutions to legal problems and achievement of both purposes of copyright, patent, trade secret, trademark, and unfair competition law. It is hoped that in the next decade, the courts and Congress will provide software manufacturers with reliable methods of protecting their valuable investments in software. Although test cases are themselves costly and time-consuming, the benefits to be reaped by an entire industry may outweigh the economic burdens.

Clearly, the outcome of many of these issues will affect the educational community's ability to utilize and purchase new electronic hardware. Educators need to know their legal rights and obligations, and manufacturers want to ensure effective protection for their software. Thus, it is necessary to answer several questions such as:

- How should software be protected while recognizing the competing interests of groups who use software or benefit from its use?
- How can piracy and the various types of misappropriation of software be better dealt with?[86]
- How can the incentives be increased for software innovation, especially educational software, when protection entails costly judicial remedies?

While it may take some time before intellectual property law protection of software is clarified, education groups have been involved in the process. They have proposed that new, uniform legislation dealing only with software be enacted. Alternatively, they have proposed that legislation exempting the educational community from liability for use of copyrighted materials be adopted. They have considered bringing test cases into the courts against pirates of educational software on one or several of the grounds of protection outlined herein. While it is clear that the economic and social stakes are high, these efforts by the educational community are aimed at clarifying the software protection laws for the benefit of all software publishers and users.

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[85] R. A. Stern, "What Should Be Done About Software Protection?" *European Intellectual Property Review*, vol. 3, No. 12, 1981, p. 341.

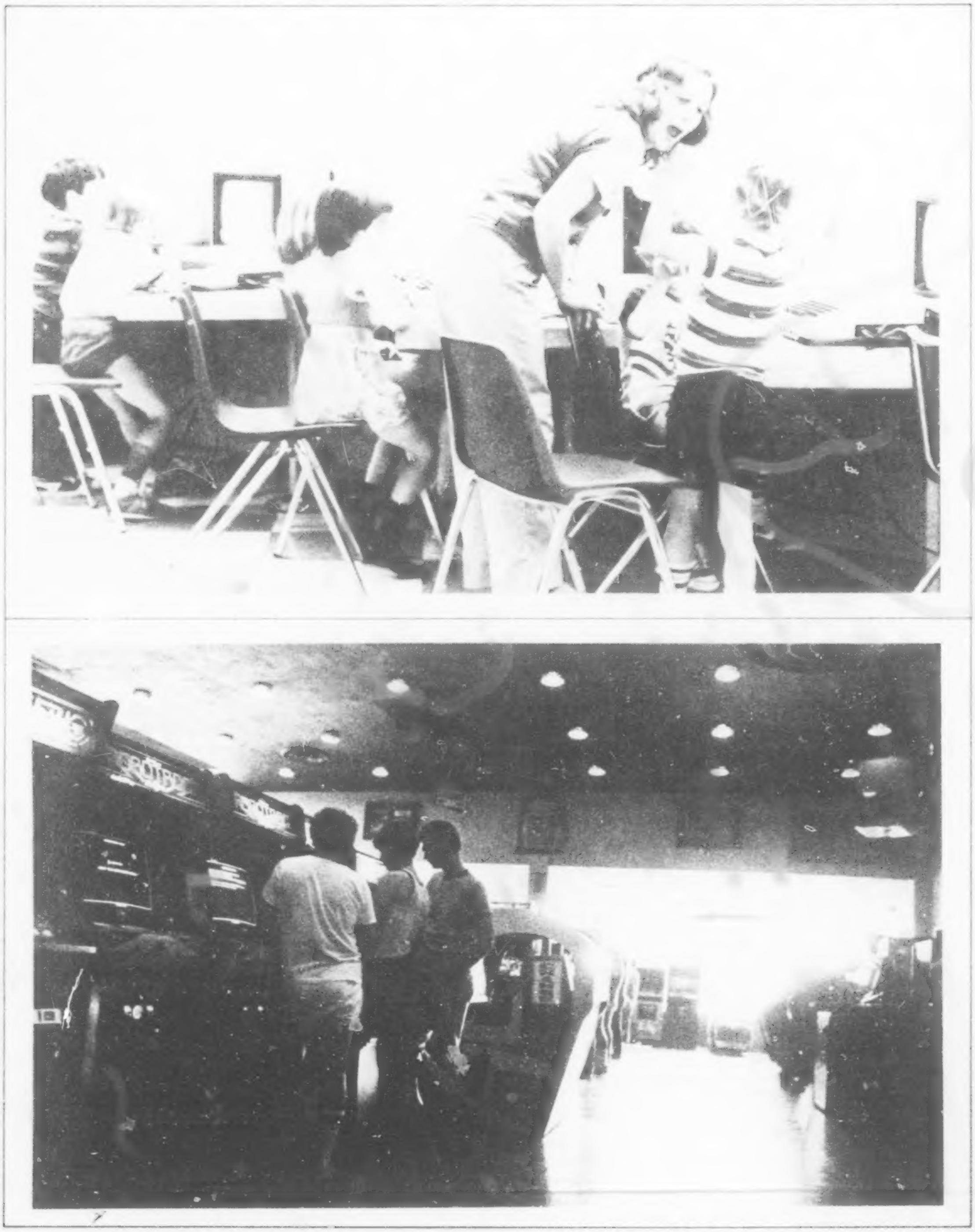
[86] Ibid, p. 340.

Appendix

- *Title I:* "To provide financial assistance . . . to local educational agencies serving areas with concentrations of children from low-income families to expand to improve their educational programs (to meet) the special educational needs of educationally deprived children" (Public Law 89-10, title I).
- *Title II:* Provision of grants to public and private schools for school library resources, textbooks, and instructional materials, based on total school enrollments. Those materials used in the public schools required prior approval. Also those States, with laws prohibiting involvement with parochial schools, required the ESEA programs to be administered by the Commissioner of Education.
- *Title III:* Provision of grants by the Office of Education with concurrence by the State Educational Agencies for projects to encourage educational innovation. Such projects included special education centers, instructional equipment, guidance counseling, and similar services.
- *Title IV:* Provision of grants to conduct educational research.
- *Title V:* Provision of grants to State agencies to strengthen planning, administration, and dissemination of statewide educational data at the State agency level.
- *Title VI:* Placed a restrictive clause on Federal involvement in State and local education programs, specifically over curriculum, personnel, instructional materials, and administration.

Chapter 10

Implications for Policy



The new information technologies offer a promising mechanism for responding to the many challenges facing American education. How they will be applied will be determined, in part, by governmental policies

Chapter 10

Implications for Policy

Whether or not the new information technologies fulfill their educational potential will depend, in part, on the kinds of actions that the Federal Government takes to assure that these technologies are used effectively and are made accessible to all. OTA has identified several areas where it may be appropriate for the Federal Government to play an active role in its development. Anticipating structural changes in the economy and the growing need for a highly literate and technically trained work force, Congress might wish to encourage the greater use of educational technologies for manpower training and retraining. Recognizing the educational benefits that can be derived from the use of information technologies, Congress might take steps to assure that the public has equitable access to them. Aware of the powerful nature of the technology, Congress might take some actions to encourage their effective development and use.

Directly or indirectly, Federal policy to encourage the use of educational technology would influence a number of stakeholders, among them:

- institutions that provide education and training,
- clients for educational services,
- producers of hardware and providers of information services,
- producers of curriculum, and
- employers.

Legislation could be addressed specifically at any of these groups—direct funding for schools to purchase technology, support for students taking technology-based education, tax writeoffs or subsidies for donations of technology and services, support for the development of curricula, or incentives for employers to provide job training.

In turn, all of these groups, and their potential use of technology, will be influenced by the shape of education policy. Decisions made by Congress will determine the roles various institutions will play in the education system of the future. They will determine which options for education and training are available to citizens, as well as which citizens will have access to them. The information industry may also be affected. Policy will influence industry decisions about what technology and services to develop and market to schools. It will affect whether curriculum producers will develop high-quality, technology-based material. Finally, policy may influence the nature and level of skills that employees bring to their jobs and the choices employers will make about in-house training and retraining.

Arguments for Federal Action

Arguments in favor of adopting a policy in support of educational technology are based on the premise that the changes in American society are creating new requirements for education and training. They are based, in particular, on the view that computer-based automation in the manufacturing and service sectors will require workers who have new skills and who can be continually retrained as changes occur and new technologies are adopted. To be retrainable, the entering work force must first be educated to a high level of basic and technological literacy. There will also be a high and growing demand for scientific and technical experts.

It appears that the educational system as it is currently structured and operating will be unable to fill these needs. Many public schools face problems such as decreasing taxpayer support and a decline in the quality of entrants into the teaching profession. While new commercial educational institutions may emerge to provide necessary educational services, their existence may present a serious challenge to nonprofit and publicly funded schools. In making decisions about educational technologies, Congress may want to take into account how their application and widespread use may affect the roles of present educational institutions.

Information technology could be a major tool for responding to these challenges. It could enhance the productivity of existing institutions and serve as the incentive for the growth of new educational and training services and of new institutions to provide them. If these technologies fulfill their educational potential, the Nation as a whole would benefit from the widespread adoption of educational technology by both schools and other education providers. The Federal Government might decide to take an active part in the adoption of these technologies in order to assure their equitable distribution, to overcome barriers to their use, and to support the national dissemination of information.

OTA found that, while many schools are adopting the use of desktop computers, there is concern among educators that many schools may be left behind. For a variety of reasons—lack of funds, lack of information, unmotivated faculty, or parents—these schools may not elect to use the technology. Such a choice could consign their students to poor employment opportunities and could lead to greater disillusionment with, and thus loss of support for, the public schools. Most importantly, it could result in substantial inequities in the way that educational services are distributed.

Some experts think that the development of good, innovative curriculum materials may be too expensive for the currently limited and fragmented market to bear. Not enough schools use computers, video disks, and other technology to provide a large enough sales base. Under these circumstances curriculum producers will be either inhibited altogether from producing material, or they will concentrate on those few applications--such as professional retraining—that have a high income potential at the expense of more basic education. Furthermore, significant developmental work remains to be done before the technology can reach its full potential. The Federal Government might provide the high-risk, critical-mass funding needed at this time to stimulate the development of a technology-based curriculum market.

Finally, mechanisms for combining and sharing experience gained from the existing activities are needed. Some experts have pointed out a need for one or more national clearinghouses to review and evaluate educational software, as well as for research centers where new techniques and materials can be developed. Again, Federal leadership is a means for creating or aiding the development of such nationwide activities.

Arguments Against Federal Action

Some experts have also raised a number of concerns about Federal involvement in stimulating the educational use of the technology. Basically they argue that the private sector can and will respond to the needs for improved education, and that education policy is the proper domain of local and State governments alone.

Federalism has been a major element of educational policy debates for many years. If the Federal Government were to undertake action to encourage the development or use of educational technology, it is likely that concerns will be expressed about undue Federal interferences in choices considered to be most appropriately made at the local level to suit local needs. These concerns would be particularly strong if Government funds were used to develop curricula.

Any new program initiatives will be carefully scrutinized for their budgetary impacts. Although few policy options appear to be extraordinarily expensive when compared to other education and research and development budgets, the Federal education budget is shrinking rapidly. Any increase of funding for technology, no matter how modest, will appear to be at the expense of other educational priorities that are already being tightly pressed.

Another important concern is that a Federal education policy that focuses on technology might create the impression that technology is a panacea. Such an impression could divert attention as well as funds from other significant problems that may not be solvable by the technology. It could also create overexpectation followed by unwarranted disillusionment about the potential contributions technology could make to education.

Finally, some concern has been expressed about the potential long-term effect on learning that may be caused by an extensive use of technology for education. Society would be augmenting or even replacing an old and well-known process—the classroom and teacher—by new technology-based methods. Some people anticipate a number of possible side effects that might have significant negative consequences for students. These effects might include shortened attention span, loss of effective learning, or decreased opportunities for social interaction.

Congressional Options

OTA found that a broad range of Federal policy options relating to educational technology have been suggested. They range in scope from policies that call for no Federal action to those that call for a marshalling of Federal resources. All of these policies would, however, be inextricably linked to the broader education policy, which has recently been the focus of significant restructuring. Since OTA has not attempted to perform an overall assessment of Federal education policy, only a broad overview of the structure of some of the more feasible options available has been taken.

Option 1: Subsidize Hardware

Legislation has already been introduced to help schools obtain information technology. For example, H.R. 5573 is intended to increase the amount of tax deduction allowed to manufacturers for donations of computer hardware. Such a policy would likely increase the number of donations of technology to schools, although the quantity would depend on the growth of the market. Firms with a large backlog of purchase orders might be less inclined to see an advantage in donations, even if accompanied by tax writeoffs. On the other hand, incentives such as advertising, long-term market development, or a sense of public responsibility might encourage contributions.

On the negative side, some have suggested that schools might be the recipients of obsolescent machines as manufacturers clear out their inventories prior to the introduction of the next generation of systems. Moreover, schools might tend to accept inappropriate hardware that is free rather than purchase equipment that best fits their needs.

One congressional option would be to increase direct funding to the schools to allow them to purchase hardware. Such a policy would have the advantage of allowing the institutions to select the equipment they prefer. The OTA case studies indicated that many of the most successful schools that now employ computers used Federal funds as seed money for their programs. Desktop computers can be used to teach introductory computer programming and computer literacy without extensive software. Such a course characterized the initial use of computers in many of the schools that OTA examined. In addition, a substantial increase in the base of hardware available in educational institutions would provide a more attractive market for curriculum producers. It could both encourage the development of material and decrease the price of software since development costs would be written off over a larger sales base.

Option 2: Subsidize Software

Many producers of educational curricula are interested in the growing market for technology-based materials, but they are uncertain about entry. In the early, formative stage of the market development, expensive development projects are risky, at best. In addition, much still needs to be learned about the best educational use of the new media. These problems have served to slow the pace of development.

In response to these problems, some have suggested that the Federal Government provide assistance with developmental costs of some major curriculum packages. Either direct funding, full or partial, could be provided to the producers, or educational institutions could be given funds for the purchase of educational sofware.

Direct support of the producers would allow the Federal Government to set priorities in two ways. Curriculum packages could be designed around those subjects for which a clear national need exists—e.g., mathematics and science, foreign language, or adult literacy. And research and development concerns could be taken into account when setting priorities for projects to be funded. Support could be given to those that showed the most promise of advancing the state of the art in the uses of education technology. Opponents of such an approach suggest that priorities for these two concerns are best set at the local level and in the marketplace.

An alternative method of support that takes these objections into account would be to provide educational institutions funds to purchase educational software. Such a policy would increase the size and likelihood of a potential market for software and encourage producers to compete for a share of that market. Priorities for subject matter would then be set in the market by the users and producers, and competition would result in increased quality and decreased costs. Opponents argue that many potential educational users are not yet sophisticated enough to exercise their best judgment. Their naivete, coupled with the expenditure of Federal rather than local funds, could encourage wasteful expenditures on well-marketed but educationally unsound curriculum packages.

Option 3: Assume a Leadership Role

The lack of information by the potential users of educational technology is the basis for suggestions that the Federal Government play a leadership role, particularly with respect to the elementary and secondary schools. Few teachers or school administrators are trained in the instructional use of computers or other electronic media. Unsound decisions in implementing technology and selecting curriculum packages could be extremely costly to schools. Money would be wasted, and potential benefits could be lost. Furthermore, exaggerated expectations or a bad initial experience with technology resulting from a poor implementation strategy could lead to disillusionment with educational technology and to significant delays in its appropriate implementation.

At the same time, OTA case studies suggest that, at least in a number of schools, there is a great deal of interest and motivation by faculty and administrators, students and parents, and local industries to promote the use of computer technology. This motivation, if properly informed and guided, could be an important driving force for the implementation of educational technology.

The Federal support might take the form of funding for teacher training, either inservice or preservice in the teacher colleges, for demonstration and development centers, or for information clearinghouses. Such activities might be undertaken directly by the Government, or through the encouragement of a variety of institutional partnerships involving education, industry, and nonprofit foundations interested in education. S. 2738, for example, would provide tax credits to firms that hire public school math and science teachers during the summer.

OTA has found general agreement that there is a significant lack, particularly in the area of precollege science and mathematics, of qualified teachers. The concern has been expressed both about the numbers of teachers being trained and their quality. The Federal Government has funded teacher training programs in the past, particularly in areas where there was a vital national need. For example, inservice programs in science and mathematics education were funded by the National Science Foundation.

A major problem noted by some experts and administrators in the area of computer training is the natural competition of the private sector for people with abilities in this area. One effect of the growth of the knowledge industry has been to increase the earning power of individuals with expertise in science, mathematics, and engineering disciplines. This trend is particularly apparent in the computer-related fields.

This problem creates a need for more teacher education. However, it also suggests that, while salaries remain significantly lower in education than in other sectors, teachers who receive such training would need to take this possibility into account, through mechanisms such as:

- making commitments to the teaching profession part of the selection criteria,
- making contractual agreements with teachers attending the programs that they will return to teaching,
- making agreements with local industry not to lure teachers newly trained in computer technology,
- setting up cooperative programs with local industry to provide summer jobs to teachers that have been trained in computing, and
- using differentials to encourage teachers with more marketable skills to stay in the education profession.

The clearinghouse and demonstration center suggestions respond to the other major nonmonetary barrier: lack of information and guidance on how to institute and use educational technology. For many years, suggestions for various forms of such centers have been put forth. They could perform a wide variety of functions, including the following:

- evaluate educational software and disseminate their findings. The extreme case of this review process would be for the center to certify software as educationally valid;
- provide a location and experienced staff for teachers and administrator training programs;
- provide expert consulting and guidance, since salaries at such a center might be more competitive;
- serve as an instructional test bed for both new technology and new teaching techniques that integrate instruction and technology; and
- identify and examine in detail those institutions that have already successfully adopted technology in order to share their experiences more broadly.

Option 4: Incorporate Technology Initiatives in General Education Policy

Congress makes policy that broadly addresses the general problems and needs of education. This broad legislation could be tailored where appropriate, either to encourage technological use or to remove unintended barriers to such usage.

To the extent that education legislation is created based on a view of the educational system—needs, providers, and mechanisms—policy should also take into account the possibility of change from the information revolution. For example:

- Vocational education must take into account the problems of experienced workers displaced by automation and the new skill requirements of high-technology industry.
- Veteran's education must consider whether continuing adult education will shift focus from schools to industry or even to the home.
- Special education will need to consider the enormous potential of information technology to improve the access of handicapped to the information stream of U.S. society and, hence, to educational services specifically tailored to their needs.

Impacts

Any policy relating to educational technology will need to be evaluated, not only for its direct effect, but also for the potential it holds for longer term impacts. OTA has identified three general areas of potential impact that seem particularly significant for Federal policy.

Implicit Choices

Congress could influence the long-term development of the educational system through policies that deliberately or unintentionally favored particular institutions, clients, or technological mechanisms. As a result, there could be significant long-term effects on who is educated in our society, for what purpose, who provides it, and what mechanisms are used to provide it.

OTA found that a variety of new providers of education and educational material are appearing and that the roles of traditional institutions are shifting. It is possible that information technology will be a powerful tool for decreasing costs of instruction or for increasing the quality, distribution, or variety of educational offerings. If so, those institutions that are able to adapt to its use most quickly will have a significant competitive advantage over those that cannot. By focusing on the needs of one or more of these institutions—e.g., the public schools, libraries, or industrial training facilities—at the exclusion of others, Congress could influence that competitive balance.

Certain objectives may overtly dictate such policies. For example, if it were determined that public school's lack of access to educational technology put their students in a severely disadvantaged position, Congress could, for public policy reasons, focus policy on public schools in order to strengthen them institutionally. If it were determined that the proper Federal interest was to see that information literacy increased among the population in more general terms, policy might address the needs of libraries or museums. Policy that addresses the need for job training might concentrate on industrial education.

Certain clients for educational services may also be favored over others. To the extent that different institutions serve different sets of needs, the policy impacts on institutional roles discussed above will also affect the clients. In addition, a number of Federal education policies—those concerned with special education, foreign language instruction, etc.—are specifically tailored to the needs of particular learners.

Finally, policy may be directed at specific technologies. OTA found that a wide variety of computer, telecommunication, and video technologies have potential educational application. Furthermore, they can be combined in new and unexpected ways to form instruction systems. Policies narrowly focused on one technology—microcomputers, two-way cable, etc.—could inhibit the full exploration of the potential of the much wider collection of information technologies.

Potential Equity Impacts

OTA found concern among some experts that the widespread implementation of educational technology could create issues of equity. Information technology could accelerate the existing trend of educational services moving into the private marketplace. To the extent that such a trend affects both the cost and accessibility of instruction, it may have a differential impact on the ability of groups within the society to become educated. The cost of education may increase beyond the economic means of some. Providers may not have an incentive to meet certain needs if they see less potential for profit in them. Regions may be geographically isolated, without access to vital telecommunication technologies that could provide needed educational services.

On the other hand, information technology could also substantially improve access to high-quality educational services. Communication services such as direct broadcast satellite can bring instruction to remote areas. In-home information technology such as two-way cable and personal computers can improve the homebounds' access to education. Technology could provide effective education in areas such as bilingual education, supplementary tutoring for children with learning disabilities, or assistance in classroom communication for the physically handicapped.

To the extent that Federal policy influences the impact of educational technology on access to education, it will also likely influence both the access of affected groups to jobs and their ability to participate in an increasingly complex society.

Long-Term Educational Impacts

Finally, over the long term, a major societal dependence on information technology could have significant educational and psychological effects on the U.S. population. We have little information about what those effects might be. While the educational effectiveness of information technology seems generally to be accepted, not much has been learned about the more subtle effects on learning or the possible impacts of more extensive, longer term use. Most likely, some skills will be enhanced by use of technology while others may be lost or lessened.

To the extent that changes do occur, there may be concomitant changes in the skills demanded by society. For example, some experts argue that simple arithmetic skills may be less important in a world of pocket calculators and automated cash registers, and that spelling may be less important in light of modern word processing systems that correct errors. Even more importantly, if more and more jobs may require the use of computers and automated data bases to solve problems, then the skills that are particularly enhanced through interaction with a computer-based education system may be very important in the future.

The analysis of potential policies and their impacts suggest that, while any particular action will affect the future use and development of educational technologies, none of them can, by themselves, meet the total challenge facing American education today. As this OTA report demonstrates, to meet the educational needs of an information society will involve all individuals, groups, and institutions. It will require the use of a full range of educational approaches and technologies. It will, moreover, entail overcoming a wide variety of complex institutional and social barriers. And it will necessitate a thorough understanding and the continued monitoring of these rapidly unfolding technologies.

The information age is having a profound effect on American education, increasing the need and the demand for a broad variety of educational services. The Nation's educational needs are not now being met, creating a situation that could impede the Nation's economic growth, undermine its international competitive position, and increase and exacerbate the socioeconomic divisions within society. The new information technologies offer a promising mechanism, and in some cases the only mechanism, for responding to these educational needs. Their widescale application will significantly affect how and to whom educational services are provided. Such changes will present both challenges to and opportunities for American education. Congress could take a number of specific actions to affect the development, educational application, and distribution of information technologies. But such an approach would address only a single aspect of the problem and may generate undesirable and unexpected side effects. If this is to be avoided, a broad approach, which takes into account the changing needs for education and training, considerations of equity, and changing institutional roles, will be required.

Appendix

Appendix A

Case Studies: Applications of Information Technologies

This appendix presents a series of case studies exploring the applications and uses of technologies in a variety of institutional settings. All were chosen to depict current, state-of-the-art uses within institutions where application has been successful.

The seven studies describing information technology in the public schools were selected to include examples from the Northeast, Midwest, South, West, and Far West regions of the United States—and to include rural, suburban, and urban school settings. In choosing sites to visit, the major criterion was that activities involving technology were already under way and well-established. These cases were also selected to cover a variety of instructional uses of computers; computer literacy, computers as instructional delivery systems (CAI-CMI), and computers as tools for problem-solving.

Three case studies of applications of information technologies in corporate instructional programs are presented to illustrate computer-assisted instruction, computer-managed instruction, computer-based simulation, video disk, and teleconferencing. The studies have been drawn from the airline, high-technology, and tobacco products industries.

Use of information and communication technologies has affected all aspects of library services. With a broad overview of different applications within different types of libraries, there are examples of new and innovative programs that are local, county, statewide, and national in scope.

As in libraries, information technology has changed the nature of educational services provided by many museums. Recently, more and more museums have been incorporating information technology, particularly computers, into both their exhibits and their educational programs. A survey of the uses of the technology in museums and a case study on a new childrens' museum in Washington, D.C., are included to demonstrate current programs.

All branches of the military have made substantial investments in research and development (R&D) on applications of information technology to education as well as investments in ongoing programs utilizing these technologies. Descriptions of some of the military's educational programs are included to illustrate the types of programs funded, the range of educational needs found in the military, the uses of information technology to address these needs, and the extent to which these programs may be applicable to the civilian educational sector.

Two other sections—information technology and special education, and information technology in the home—are also included in this appendix. Since special education is a field, not an institution, OTA did not fully explore the uses, impacts, and effects of these technologies in this area. However, because the technologies will considerably affect the schools in general, OTA examined the possible application of these technologies for teaching the gifted and the handicapped. In a similar vein, OTA took a broad overview of educational services that are now available to be delivered directly to and in the home.

Computers in Education: Lexington Public Schools Lexington, Mass.

The Computers in Education program of the Lexington, Mass., public schools was selected for study because the district is considered to be a leader in the application of computer technology, with experience and expertise that spans over 15 years. Located next to Route 128, the home of a thousand high-technology companies, the district typifies a community where parents' technical expertise, leadership, and support have had a significant impact. The Lexington experience illustrates a variety of computing applications, developed by individual teachers with leadership from the district's long-range planner and computer specialist. The program also demonstrates a major planning effort involving teachers, administrators, and parents. This 2-year effort has resulted in a comprehensive blueprint for computers in education that depends on the district's continued ability to handle financial constraints (Proposition 2½) through frugal budgeting, redistributing available funds, and forming new partnerships with the community (town government) and the private sector.

Fifth grade students (at left) at Fiske School, Lexington, Mass., gather about their homeroom's computer console, linked to the Lexington School System's mainframe Digital Equipment Corp. computer, housed at the Lexington High School. The computer is made available to all of the students in the class, much as are books, activity files, maps, records, and educational materials of all nature. Their homeroom teacher assigns students to the keyboard on a rotating basis, giving them assignments which enhance their computer literacy

The Setting

Lexington, one of the suburban towns that surrounds Boston, is located in the heart of the State's booming high-technology area. Many of the Lexington parents and community members are employed by the nearby technology industries in white-collar technical and managerial positions. There has been continual and strong community involvement and support for the schools, with a tradition of community participation in town governance and decisionmaking.

Contrary to trends in other districts, 90 percent of Lexington parents send their school-aged children to the public schools. Assistant Superintendent Geoff Pierson observes that the flight to private schools has not occurred because "there is consensus about what the schools are doing and parents feel that the schools represent their children's interests."

Lexington is also a relatively homogeneous, affluent, middle-class community. The school-aged population is 95-percent white, 3-percent black, and 2-percent Oriental. Seventy percent of high school graduates go on to a 4-year college. Lexington boasts of having the largest number of merit scholars in the area, in part because there are many "smart kids" in the system, but also because "our program is rigorous and interesting."

A total of 5,625 students are enrolled in grades K-12 in seven elementary, two junior high, and one high school. Five years ago, the district, accurately projecting serious enrollment declines, planned and prepared for significantly fewer students. Over that period five schools were closed and 150 teaching positions were abolished, while teacher/student ratios were held constant and the number of instructional programs was increased. According to Superintendent John Lawson, declining enrollments, continuing inflation, and the passage of

Proposition 2½, resulted in the allocation of fewer resources to the public sector.

However, Lawson states that the school administration and the school committee have avoided serious problems by planning carefully and spending frugally. "In an era of limited resources we have had to develop better priorities, monitor our successes, and determine where we want to go next." Not all parents and staff have been happy with the budget decisions and allocation of resources, but they agree that Lexington has fared better than other districts in the State. There is consensus that the over $17 million 1981-82 budget, with a $3,024 per pupil expenditure, supports a comprehensive, high-quality educational program.

Computer Applications in the District

The district's first computer, a Digital Equipment Corp. PDP-8 with 14 terminals, was purchased with Federal funds by the mathematics department in 1965. Math-related computer courses were first offered to high school students, and a year later to junior high school students. As teachers and students became involved, interested parents worked with them to develop software, to expand programing skills, and to train others.

Spearheading all of the computer activities, Walter Koetke, computer coordinator (no longer with the district), encouraged parents and teachers and, according to many, demystified computers. He taught his colleagues BASIC, designed software for the system, and set the foundation for Lexington's computer applications. A math specialist trained by Koetke worked with an advanced group of primary students, transporting these youngsters to a nearby junior high so that they could have once-a-week computer experiences. One of the youngest, a first grader in the group, later became one of the Lexington high school programing stars. By the late 1960's, Lexington led in efforts to bring computer-related experiences to groups of fifth and sixth graders who were transported to junior high schools by their schools' math specialist and by parent volunteers.

In 1975, with leadership from Frank DiGiammarino (director of computer services), Koetke, and others, the district obtained funding from the Massachusetts State Department under title VI, part B to develop a computerized system to deal with the real problems of data management in a local school district. Project LEADS developed software for a wide range of management functions—e.g., budgeting, accounting, scheduling, attendance, and student and personnel data. Project funds also supported the purchase of a DEC PDP 11/40 and peripheral hardware. Shortly, this system was also used to support instructional activities at the secondary schools—primarily in math and science, but also in other areas.

Parents soon began to push for computer use in the elementary schools, locating unused terminals at work, donating personally owned equipment, and helping the schools get the hardware installed. In addition, parents and math specialists trained teachers. Because teacher acceptance and use of computers was minimal, parents took over operation of the terminals and trained additional parent volunteers to enable pupils at all elementary schools to participate. These computer activities continue to build general computer awareness and comfort and to engage students in problem-solving activities, drills, and games. When microcomputers came on the market, the Lexington computer activitists were ready to move.

The first four Commodore PET microcomputers were purchased with discretionary funds in 1978, and a half-time position for a computer specialist was created. A year later, an additional 35 PET's were purchased with Federal Title IVB funds and PTA gifts. At the beginning of the 1978 school year, workshops were offered to reach all teachers to integrate them into instruction. The plan was to diffuse computers among the schools. With a total budget of only $800, a computer specialist (Beth Lowd) was hired to work with each school; community volunteers were enlisted to write software for the PETs or adapt software from the PDP 11; and a catalog and materials library was assembled.

In June 1980, it was clear that short-term, unplanned use wasn't working. Rotation of the equipment was modified to concentrate resources in the rooms of interested teachers, and a "models" approach evolved. The wide diffusion of computers was seen to depend on successes in individual classrooms first. Another lesson learned was that the microcomputers had to be available for more than a few weeks (e.g., one semester or all year) to ensure maximum payoff in each classroom.

By 1980, more than 20 models were implemented with a focus on computer literacy and applications in math, spelling, social studies, science, and language arts at all grade levels. In each case, models were developed by individual teachers, a team of teachers, or the entire school staff. In many instances, school principals provided staff support, while central office staff wrote grant proposals to the school board to get additional funds for microcomputers, software, teacher planning time, etc.

To build awareness of computer potential and to obtain support for the ongoing activities, a 2-day leadership conference was held in October 1980. More than 90 district educators attended. Experts from Massachusetts Institute of Technology (MIT), area colleges, regional cooperatives, local school districts, and the private sector made presentations. Teachers from the Lexington district demonstrated hardware and software and structured hands-on experiences. The conference was followed by the formation of computer planning committees.

Workshops and training sessions followed that were intended to provide most of the staff some training, at least at the awareness level. Teacher participation has so far been voluntary. All of the district's library media specialists have had extensive training and, as a result, have initiated several projects: a computerized annotated listing of 16mm films; a materials data base for all nonprint materials in the district; and a computer center/library media pilot. The media specialist's role has expanded in Lexington; in recent budget planning sessions library positions were held constant, partly because of the school committee's commitment to computer activities and because of the plan to focus computer centers around the media center.

Currently, the district's 60 microcomputers, 2 minicomputers, and 33 terminals support the following uses:

Kindergarten - Grade 3
- Reinforcement of number and letter skills
- Computer awareness and independence
- Phonics instruction
- LOGO models
- BASIC for primary grades

Grades 4 - 6
- Word processing for editing
- BASIC for problem solving
- Using terminals in the classroom
- LOGO
- Skills reinforcement

Grades 7 - 9
- BASIC and computer literacy
- Word processing for writing
- Simulations in science
- Skills reinforcement

Grades 10 - 12
- Six math electives ranging from computer awareness to computer science and assembly language programing
- Business applications
- Science applications

Library
- Materials data base
- Computer center/library media center pilot

Management and Systemwide Administrative Services
- Program budgeting
- Program accounting
- Fiscal reporting
- Scheduling
- Grade reports
- Student and personnel data

Parent Involvement and Community Support

Parents have participated in the computer activities and served as a resource by:

- providing technical advice and assistance. Parents serve on advisory and hardware purchasing committees, help install equipment, troubleshoot problems, and support computer plans in school board deliberations;
- writing educational software for the time-share system and the PET microcomputers and by inputing data in the materials data base;
- helping train students, teachers, and other parents on the terminals. Parents help in individual classrooms using microcomputers, and participate in district-level workshops;
- assisting with computer clubs before and after school;
- supervising the use of the time-share terminals in the elementary schools; and
- purchasing and donating equipment. PTAs raised funds to purchase additional microcomputers. Other parents donated personally owned computers and terminals or found excess equipment that was no longer being used by companies.

Gloria Bloom—a parent volunteer, MIT graduate, and former computer programer—estimates that parents currently spend approximately 70 hours a week operating the time-share terminals in the elementary schools. Parents also come to school committee meetings and meet with the superintendent and school principals to help advance the program. Some observers of the Lexington program suspect that parents have led the educators by pressuring and demanding computer programs for their children. Parents point out, however, that educators must play the key role if computer technology is to become integrated into the educational process.

Although the major industries are literally next door to Lexington, corporate-level involvement with the school system is not direct. Rather, collaboration is primarily through the parents of the pupils or through interested individuals in the community who are also connected to the private sector. Through these individuals, hardware is donated, software is developed, company tours are conducted, and information on careers is disseminated.

Impacts

Ironically, increasing success has created problems. DiGiammarino describes the issues in terms of "the ecstasy and agony of computers." As educators' experience broadens and expertise develops, the potential uses for computers is recognized —the ecstasy. "This, however, is tempered by the realization that all the conditions necessary to reach the ecstasy do not currently exist—the agony." For example, more and more teachers are moving ahead with classroom applications, enrolling in workshops and degree programs at nearby universities, and, at the same time, requesting more equipment, software, and in-service training. The present time-share hardware systems are aging fast; the microcomputers break down and are difficult to maintain the demand is greater than the supply; and funds for teacher in-service, professional development, and sabbaticals are limited.

Impacts on Students. Students are motivated and interested in computers, and there is evidence of improved student performance through skills reinforcement drills. But the existing software for the minicomputers and microcomputers, obtained through commercial sources and parent, teacher, and student development, is limited in scope. Although high-quality software is becoming available, it is very expensive. The LEADS system has both management and instructional applications, but its users are primarily central office staff and special education staff. Its potential for diagnosis and tutoring applications and materials retrieval, however, is high. According to school officials, what is needed to make LEADS fully operational is an upgraded minicomputer, a unified distributive network, and training for both administrators and teachers—to be implemented during the second year of the long-range plan.

Finally, there is the issue of program diversity. As programs evolve, different approaches are developed by individual teachers. Each elementary and secondary school uses terminals and microcomputers, but the applications and the penetration into all classrooms varies. Some teachers have greater interest and expertise, hence their students have different experiences. Parents in some schools have become more involved, have access to resources, and are willing to push harder than others. Principals juggle with conflicting needs and set different priorities. The issue of equity in access and quality has concerned Superintendent Lawson and his administrative staff. More than any other factor, it has led to increased leadership responsibility for DiGiammarino, an expansion of Lowd's activities, and the creation of planning committees.

For members of the district's computer curriculum committee, as well as for others heavily involved with computers, the benefits to teachers, their students, and the program outweigh the problems or frustrations. Teachers point to their new computer expertise. Many have written their own programs, and others have helped design and implement computer models and curriculum materials. Mainly by trial and error, teachers have made the computer work, and they feel good about what they and their students have learned together. There is a pervasive enthusiasm.

Dave Olney, high school physics teacher, implements one of the district computer models for using the Apple computer in physics. He spends hours writing programs and expanding his own knowledge and previous experience with the DEC system. He is excited about using the microcomputer to speed up and improve laboratory activities by having students punch-in data, calculate results, and get immediate feedback. He sees a whole range of applications including the feasibility of modeling problem-solving processes in physics. His enthusiasm results from the intellectual stimulation he derives from the logic processes that he uses as he programs these activities.

For other teachers, satisfaction comes from observing the progress of their students in writing, in math and reading, or in simply feeling comfortable with computers in a variety of settings. There is no question that students are enthusiastic users. A group of third and fourth graders working with LOGO and problem-solving strategies, interviewed by their teacher, Florence Bailey, reported that learning is fun, that mistakes can be handled, that solutions can be derived through experience, and that mastering programing skills is challenging:

Eric: It's fun, but it's actually school work. It's better than recess! Brad and I make a good team. He knows things I don't know, and I know what he doesn't.

Tim: If you're bored, you just work on the computer, and you're not bored anymore.

Tanya: I can make my own designs and pictures. You're learning while you're having fun.

Chrissy: The big one upstairs is already programed. This one you can learn to program with your own things.

Shannon: You can learn by yourself . . . if you make mistakes. You can fix a circle that's too big.

Increasing numbers of Lexington students, particularly by the time they reach high school, have expertise in programing that is impressive. Ed Good, director of the high school computer math center, points proudly to students who have written software for the districts' data management system, for elementary classroom instructional activities, and for small businesses in the area. He cites the high school sophomore who designed the interface to transfer (download) programs on the PDP 11/40 to the PET's, thereby saving the district thousands of dollars.

From the models and from other uses, it appears that computers are, and will continue to be powerful tools for both teachers and learners. This notion explains, in part, why an increasing number of staff members are using computers or are interested in having computers in their classroom. Jody Josiassen, a fourth grade teacher, describes his 2-year involvement: "In my teacher training program there was nothing in my education that spoke to this—the hardware—the software. It's a brand new field. I get excited about it from a teacher's point of view because I think it can do things in the classroom for me that I've struggled with in the past."

Finally, in further justifying the comprehensive plans for future computer applications, Lexington administrators and teachers point to their high-technology community and to the increasingly technology-related world. Two-thirds of Jody Josiassen's students have their own home computers. He views this phenomenon as the "iceberg out there and I'm at the very tip." He also sees that the schools need to be part of the momentum, "to catch it, structure it and use it . . . and help my students develop their goals to use it."

The Future

Implementing the Long-Range Plan for Computers in Education. With district implementation of the long-range plan, the following examples will become not only possible, but commonplace. The planning document projections include:

- A third grade student at a computer station ready to LOAD, RUN, and LIST a program from tape or disk.
- A teacher at a computer terminal obtaining a list of all nonbook resources owned by the Lexington School System related to a specific subject heading for students at the seventh grade instructional reading level.
- Elementary school students work at computer stations in the learning center or on teacher prescribed learning activities which have been integrated into the curriculum.
- The coordinator of language arts updating the language arts curriculum data base from staff evaluative information.
- A junior high school student electing to take a followup computer course as a result of positive experiences in the required computer literacy program.
- A student at the senior high school level designing his/her own data base management information system.
- Teachers or students using computer terminals to address computerized information systems anywhere in the Nation.
- A teacher queries a terminal to determine exactly what are the educational plan objectives of two students in the class and what is their progress to date.
- A program director querying a terminal to determine the exact cost to date of his program and precisely what portion of that cost has been used for special needs programs.
- A counselor using the computer to assist scheduling a new student.
- An elementary principal, concerned about the validity of the academic level recommended for his students moving to junior high, using a terminal to examine how previous students have achieved in seventh grade relative to the level recommended by his school.
- The data-processing center adding to the data base the information from the annual battery of basic skills tests given to one-quarter of the school population. Also, printing report cards and searching for those students whose academic achievement is declining.

Acquisition and Placement of Hardware. Key implementation strategies include the acquisition of equipment over a 5-year period, with a mix of microcomputers, terminals, and replacement of the system's PDP 11/40 and 8. Each school will have a cluster of inexpensive portable microcomputers and terminals that tie into the central system. The upgraded central minicomputer system will significantly expand capacity to handle a curriculum materials data base, software collections, and student information and management functions. Each elementary school will have a computer learning center supervised by the library media specialist. A center or cluster will be equipped with the following:

- 11 small microcomputers (several available for loan to individual classrooms),
- three CRT terminals hooked to the central minicomputer,
- one printer directly tied to the central minicomputer, and
- one printer for the microcomputers networking and electronic mail equipment.

Similar centers will be established at the junior high school, with one center servicing the needs of the computer literacy curriculum as well as the academic areas outside of math and science. The second center will support math and science applications. Similar configurations are planned for the high school, as well as an upgraded computer center with a replacement of the PDP 11/40 and a phase-out of the PDP 8.

Funding. Recommended equipment will probably cost almost a half-million dollars. Up until now, computers and terminals were acquired without expenditure of local funds (see previous sections of this report). With reductions in Federal and State funds, the district is searching for other alternatives, such as corporate contributions from the computer hardware manufacturers, to defray part of the equipment costs. The school committee is also being asked to allocate funds from the operating budget to support the computer program. For 1982 to 1983, the plan is to budget $74,566 from local revenues, to use all of the Federal title IVB grants ($16,000) and reimbursements to the district for student teaching from Boston University ($10,000), and to attempt to obtain a 50 percent discount from DEC for the new minicomputer as a corporate contribution.

Although implementation of the plan is based on funding sources such as Federal block grants and other special area funds, the availability of these resources is not guaranteed under present circumstances. Furthermore, funding projections deal solely with hardware acquisition. Costs for software, continued training, and maintenance will have to be absorbed by operating budgets.

A Separate Department for Information Science. The planning committee has recommended the establishment of an information science department to lead program activities—handling staffing, budgeting, maintaining, and evaluating the K-12 computer literacy program. The department would also assume responsibility for the revision, updating, and teaching of higher level courses on programing, systems design, and computer applications. Inservice training and other leadership and professional development activities would be handled as well. Computer literacy and computer science courses would be taken out of the math department, and the scope of the program would be broadened to include all curriculum areas. No new staff positions are contemplated; staff members who have already played leading roles will be reassigned to the new department.

Training and Curriculum Development: Computer Literacy. These efforts will continue with summer workshops and inservice training activities scheduled on release days at the beginning of the school term and periodically during the year. During the summer, teachers from the computer literacy committees will work with Lowd to assemble and prepare materials for elementary and junior high school components. These teachers will be responsible for teaching the course at the junior and senior high schools in the fall. Resources (staff time, equipment, and software purchase and development) will be concentrated over the short term in grades 5, 8, and 10. Remaining portions of the new curriculum will be piloted at other grade levels.

Computers in Education. It is planned to extend the use of computers as tools for instruction. The materials data base will be operational. Because of upgraded central computing facilities, teachers and administrators are expected to increase their use of computerized data. Also expected to increase are the communication and sharing of information and software via electronic mail among all schools, as well as the number of accessing information centers and networks within the community, State, and region.

Parents and the Technology Community. Cooperative efforts with local district cooperatives and user groups, with parents, and with the high-technology industries is essential to Lexington's future. How else, argue the educators, can the district keep abreast of technological advances, encourage or demand useful and appropriate software, make the best use of available resources to advance the long-range plan, and maximize the potential benefits of technology for education?

As a result of district membership in EDCO, a local education collaboration, Lexington teachers will derive benefits from the computer resource and demonstration center that is being established. They will also benefit from the knowledge that they are not alone, that other districts are copying with computer applications, too. The regular exchange of information with such districts is welcomed by the staff. Finally, the technology community and the parents offer valuable resources. Lewis Clapp, president of a local software development company and also a parent, maintains "a school system that does not take advantage of the intellectual power of its parents and community is doing a disservice to its students—particularly in an era of 2½'s and Reaganomics."

The parents of Lexington recognize progress, but they expect more. For example, Clapp believes it is essential that *all* teachers be computer-literate; that public and higher education efforts be coordinated; that computing and computer science curricula be *fully* developed to reflect the current state of the art; that computer tools be used to support the entire curriculum, not just math or science; and that *every* student has adequate exposure to computers—"knowing what computers are all about and able to run programs—maybe even able to write their own by the time they reach high school." Clapp argues that the educational community and the public schools have a critical role to play in meeting these goals, but raises serious issues to be faced now and in the future:

> The tragedy is that national support for this is nonexistent—at the time we need it the most. The local district can't do it. Lexington—even Lexington—might not be able to (accomplish these goals) with a budget limited to a 2½ percent increase each year . . . It is a disaster for this nation. If we fail to invest in education nationally, we impact on our future and our ability to be productive . . . (and maintain) the edge we have in computers, in software, and in information retrieval.

Resources

Case study interviews:

John Lawson, Superintendent
Geoff Pierson, Assistant Superintendent*
Frank DiGiammarino, Administrative Assistant* for Planning and Research and Director, Computer Services
Beth Lowd, Computers-in-Education Specialist*
Bob Tucker, Teacher, Estabrook Elementary School*
Martha Angevine, Coordinator, Instructional Material Services, Curriculum Resource Center*
Luree Jaquith, Media Specialist Bowman Elementary School*
Beverly Smith, Teacher, Bowman Elementary School*
Jill O'Reilly, Math Teacher, Clark Junior High School
Bruce Storm, Teacher, Clark Junior High School
Jody Josiassen, Teacher, Harrington School**
Dave Olney, Science Teacher, Lexington High School
Ed Good, Math Teacher, Computer Center, Lexington High School
Louis Clapp, Parent
Gloria Bloom, Parent

*Member, Computer Planning Curriculum Committee
**Member, Elementary Curriculum Committee

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Computer-Using Educators and Computer Literacy Programs In Novato and Cupertino

Introduction

The Silicon Valley and nearby communities were selected for study because the area provides a rich source and critical mass of educators, schools, students, parents and community members, and business representatives directly involved with technology. The area is the center of the Nation's semiconductor industry. It is also the home of a growing number of educational experts and leaders in computing. There are many examples of locally developed projects sprouted by individual teachers or administrators or parents, which have developed into major programs affecting an entire districts' students and staff. These activities involving computers in classrooms also demonstrate how resources—local, State, and Federal funding, as well as parent and local experts and the private sector—are critical to implementation.

COMPUTER-USING EDUCATORS

Computer-Using Educators (CUE) is a support group organized by and for K-12 teachers, teacher trainers, and others interested in the use of computers in education. Started by 12 teachers in the spring of 1978, the organization has mushroomed to a membership of 3,500, primarily in California but also in 48 States and 13 foreign countries. Its growth reflects the phenomenal growth of educational computer applications and mirrors the grassroots development of programs in schools up and down the San Francisco Bay Area. Groups modeled after CUE have also been formed throughout the country.

Through conferences, newsletters, and meetings, CUE is a source of information and a vehicle for sharing experiences with computers, and their use in education. In addition, CUE members originated and now support the Microcomputer Center and SOFTSWAP Library of public-domain microcomputer software housed in the San Mateo County Office of Education. To quote one member:

> Learning is a never-ending process. Formal education is a small portion of this ongoing process. The role of educators is to aid the learning processes. The philosophy of CUE should be to show educators—mostly by example—the role computers can play in the learning process. Computers can be used in many ways to do many functions. The uses, functions, methods, and materials will change and evolve. CUE can help discover and show the way.

Microcomputer Center and SOFTSWAP. The stimulus for the software exchange came from a San Jose State University professor, Vince Contreras, a CUE member. He organized the exchange of public domain and individually contributed software that was deposited in the San Mateo Education Resource Center (SMERC) Library in the spring of 1980. By the time school was out, CUE members had talked several of their microcomputer industry contacts into placing microcomputers in the SMERC Library on long-term loan. Tandy (Radio Shack) and Commodore (PET) provided the first systems. Ann Lathrop, coordinator of the Microcomputer Center reports that the center now has 14 microcomputers and manufacturers help maintain equipment and provide new models as they have become available.

The center has a steady stream of users. The San Mateo County Office of Education provides space, maintenance, and support through Ann Lathrop, library coordinator, and LeRoy Finkel, the county's instructional computing coordinator. Superintendent William Jennings cites the center's benefits to the county's 24 school districts. Teachers and administrators try out equipment and software; both Lathrop and Finkel are nearby to provide help and expertise. CUE members and their district teachers and administrators take advantage of the center for meetings, training sessions, demonstrations, and evaluation of hardware and software. The center is visited by representatives from hardware companies and software houses, educators and government officials from all over the State and even educators from other States and foreign countries.

Ann Lathrop conceived SOFTSWAP, the software dissemination and evaluation project, and garnered the support of colleagues to field-test, evaluate, debug, and clean up the programs in the system. Through SOFTSWAP, teachers can purchase software or swap their original program for that of someone else. Most of the 300+ software programs are short, stand-alone instructional units; many are drill and practice exercises for the elementary school level or for remedial work at the secondary level. All were evaluated by educators and edited for factual and spelling errors, inaccurate or incomplete instructions, programing errors, etc.

When visitors come to the center, they can copy dissemination disks without charge. Single mail order disks are $10 apiece, or free if a disk with at least one original program is contributed. Each disk contains 12 to 30 programs. Since the major thrust of SOFTSWAP is sharing with the widest possible distribution, programs may be freely duplicated, but not sold.

CUE Conferences

CUE's first conference, remembers William (Sandy) Wagner, founder and first president of CUE, evolved from CUE's early meetings. "We'd introduce ourselves, share ideas on curriculum, on software . . . and see more new faces each time. By September 1978 the small group had grown to 50 and it was agreed that "we can't go on meeting like this" . . . a conference would facilitate sharing and in-depth discussions. CUE's first weekend conference in January 1979 attracted 65 educators. A few informal sessions expanded to multiple presentations, wide-ranging exhibits, and hands-on workshops in the fall 1980 conference with 500 in attendance. By fall 1981, conference attendance reached 1,400—with some districts sending all their teachers to view 45 commercial exhibits and 60 different speakers. CUE's officers and executive board members play critical roles in planning, organizing, and running the CUE conferences. They work evenings and weekends—all on volunteered time. The conference coordinators handle some tasks with their own personal computers, as well.

Impacts

The expansion of CUE membership and activities demonstrates not only the growing interest and use of technology in schools, but also the fact that teachers need help. They are coming for more than help, some argue—they're looking for leadership. These computer-using educators "are carrying the message that the time to move is now," notes Arthur Luehrmann, former director of the Lawrence Hall of Science Computer Project. "The leaders are here in these counties who are responding to the signals coming from society, from the employers, and the parents."

When asked why CUE and the grassroots phenomenon developed where it did, many point to the "critical mass" of people that emerged—individuals developing separate programs and expertise, but living close enough to meet. Finkel points to the special and unique aspects of CUE. "CUE members are teachers first. We share, we don't have district or school boundaries. We're a network of people . . . and it's a stupendous event each time we meet." Furthermore, there was a need for support, training, information, and leadership that neither the State education agency, the institutions of higher education, nor the high-technology industries were providing.

Future

There are indications that the latter situation may be changing, albeit slowly. The Fremont and Los Gatos High School districts plan to open a joint Silicon Valley High School with support from the Industry Education Council. Equipment and training for teachers are being solicited from high-tech industries. The high school will offer entry-level vocational training and courses for the college-bound information sciences major who wants a head start, and for other college-bound students who want to learn how to use the computer and related tools in their studies and future work. Governor Brown of California, in his address before the State Legislature in January 1982, called for new priorities and action:

> Our schools must augment the three R's with the three C's—computing, calculating, and communicating through technology. We will do so or succeeding generations will inherit a society stagnating in the aftershocks of massive foreign imports and obsolete industry.

In addition to the first priority of an increased commitment to mathematics, science, and computer instruction in California K-12 schools, the State Education Agency is beginning to address technology issues. One issue that concerns many of the local educators is how to meet these commitments, given the growing disparity between districts that have programs, trained teachers, and community resources to draw on and those districts that do not. Furthermore, not every district or county in the State has a major industry to draw on. Even in the Silicon Valley much of the private sector is made up of small, short-term, entrepreneurial businesses that don't have extensive resources.

In reflecting on the grassroots development and the enthusiasm of CUE, Joyce Hakansson, formerly at the Lawrence Hall of Science and now a software designer and developer, cautions: "We need to understand the place of technology and give it a proper role. Don't assign all of our ills to technology . . . recognize that technology is just another tool." Hakansson notes the new status and positive feelings of self-worth resulting from interaction with microcomputers, but also observes that, "software, the essence and heart of the computer, is less than it could be" and that "what youngsters are doing on computers may not be worth the time or money." The future applications ought to capture the inherent interest and motivating aspects of the technology and match it with children's learning needs—to integrate computers into the teaching and learning environment.

From the Silicon Valley and surrounding San Francisco Bay Area communities, two school districts were studied. These districts' educational computing programs were locally developed and typify the area's grassroots activities. Key personnel from these districts are heavily involved in CUE: Bobby Goodson, from Cupertino, is CUE's President and Helen Joseph, from Novato, is a member of CUE's executive board. In-depth discussions of school district approaches to implementing computers in classrooms follow: The Novato Unified District, a rural K-12 system at the northern tip of Marin County, and the Cupertino Union K-8 district in Santa Clara in the center of Silicon Valley.

Novato Unified School District, Novato, Calif.

The Setting

Located at the upper tip of Marin County approximately 30 miles north of San Francisco, Novato Unified School District (NUSD) is one of two districts in the county combining elementary and secondary schools. It is the largest of the districts in Marin County. It is also more rural and less affluent than other areas in the county. Agriculture predominates; the major local industry is insurance—the Fireman's Fund. Incorporated in 1961, Novato's community is diverse: blue collar workers, many San Francisco commuters, a growing number of retirees, and personnel and families on the military base. The student body composition is 90-percent white, 5-percent Asian (and increasing), 3-percent Hispanic, and 2-percent black. Three-fifths of Novato graduates go on to college.

In recent years, student enrollments have declined and several schools have been closed. The present enrollment of 8,642 is expected to decrease further and level off to 7,500 by 1985. Presently, there are eight elementary schools, grades K-6; three junior highs, grades 7-9; two high schools, grades 10-12; and one continuation, grades 9-12. One junior high school is targeted for closing at the end of this year. If Novato can find buyers for the surplus school properties it owns outright (three sites are currently for sale), the interest from these revenues can be used for equipment and capital improvements.

Local educators point out that while Marin County boasts the highest per capita income in the Bay Area, Novato is the "poorest part." The 1981-82 NUSD annual budget is $23,645,286. One-fifth of the budget is federally funded. School finances are and will continue to be a growing area for concern. Superintendent Ronald Franklin explains the district's bind:

> Parents expect that educational programs will reflect excellence . . . the toughest thing we have to deal with in being able to handle our commitment (to the district's computer and other programs) is the uncertainty of the financial posture of both Federal and State governments.

Novato's board and administration are concerned because they see cuts coming on all sides. The district's Federal impact aid has declined from a high of $938,714 in 1977-78 to $602,324 in 1981-82. In 1982-83, impact aid is uncertain. State funds, which provide 70 percent of the district's revenue, have been cut, including categorical aid for special education and gifted and talented programs. Educators note that the impact of Proposition 13 passed 4 years ago, is now being felt, since the State's surplus has been depleted.

Computer Applications in the District

Computer education in the district began 8 years ago, when a Novato junior high school acquired a teletype machine and shared with Dominican College the lease of a telephone line hookup with the time-sharing computer at the Lawrence Hall of Science in Berkeley. Novato was one of several school districts linked to the Hall's Computer Education Project (funded by the National Science Foundation). The Hall staff, Lee Berman and Joyce Hakansson, were invaluable resources as computer activities evolved, relates Helen Joseph, computer resource teacher and coordinator. Even after the time-sharing project ended, she continued to turn to them for advice and support.

The district's first microcomputers were acquired in 1977, when the time-sharing costs were escalating. Richard Melendy, former math and science coordinator, now school principal, and Joseph met with the district's director of instruction and examined how the district might best use the MGM (mentally gifted minor) funds which had supported the time-sharing project. The subsequent decision to purchase Commodore PETs was based on cost and reliability.

Over the next 3 years the computer program grew rapidly, expanding to the two senior highs, an additional junior high, and an elementary school. In this small district, officials made an early decision to standardize hardware because of teacher training, software acquisition, and maintenance requirements. By 1980, there were 28 microcomputers purchased with MGM State funds, magazine sales money, and district minigrants.

The development of the program by Joseph and Melendy had strong support from the district administration. There was consensus that before the district went further, an external assessment and evaluation was needed. Arthur Luehrmann, former director of the Computer Education Project at the Lawrence Hall of Science, spent 3 days in Novato in March 1980, meeting with more than 50 people —students, teachers, parents, principals, district administrators, and school board members. In addition to identifying current needs and recommending future directions, the strategy was to involve and educate all those concerned with computer education in the district. Luehrmann's report stated:

> The present state of computer education in Novato is better than the average situation one sees in Bay Area districts today. One finds a solid base of computer equipment, several experienced and creative teachers, a larger number of interested teachers, student demand for increased access to computer classes, strong administrative support at most of the schools, and outstanding work at the district office in planning and managing the development of computer education programs in the district during the past several years. The parents and school board members with whom I spoke were also supportive of the aims and accomplishments of the programs thus far.

Specific findings indicated that primary uses were in the secondary schools, where computer programing courses and that computer literacy activities closely identified with mathematics predominated. Demand for classes exceeded supply, and teachers wanted more inservice training.

Luehrmann recommended a cluster arrangement for each of the five secondary schools, involving approximately 15 computers connected to a central disk unit and printer. Further, he recommended that the two high schools acquire computers that would facilitate instruction in a second programing language. In the elementary schools, uses were to continue to be limited to gifted programs in view of the district's current priorities and available resources. Luehrmann encouraged the development of a de facto computer education department, composed of the teachers of computing to develop curricula, course content, sequencing, and evaluation. He suggested that the district also look at administrative computer uses, drill and practice, and other CAI applications. Finally, he recommended a gradual expansion of the program over a 3-year period, with a projected cost estimate of $110,700 for equipment.

The administration and school board approved the recommendations. In fiscal year 1980-81, $30,000 from local funds and IVB Federal moneys were used to equip the junior highs. A request for funding the second and third phase of the program was submitted to the Buck Foundation, but was turned down. In fiscal year 1981-82, the second phase was funded, again from the operating budget, and one high school is to be equipped with an Apple lab.

Current Programs

Novato's computer education activities focuses on how to use the computer and include programing, problem solving, logical thinking, and debugging (tracking down errors). All seventh graders have a minimum of 3 weeks of a computer literacy unit that includes an overview, a historical perspective, basic terminology, impacts on society, and career awareness. This unit is followed by 2 weeks of hands-on experiences running programs (modeling programing activities, games, applications) and writing programs. Students can also take elective programing and math enrichment courses. One high school offers courses in BASIC and one offers courses in BASIC and Pascal. The few computers in four elementary schools are used for computer awareness activities in upper grades and for enrichment in the gifted and talented programs. A total of 77 computers are used throughout the district.

Staff Training Programs and Workshops

All administrators attended districtwide workshops because the Superintendent felt, "There was a need for every manager to know why we were supporting this program." The district also supported numerous teacher workshops run by Helen Joseph and encouraged staff to attend area workshops, conferences, and meetings. With the training activities of the Marin County Teachers Learning Cooperative, a 3-year federally funded teacher center, CUE conferences and workshops, and the increasing number of courses taught at nearby colleges, there have been many opportunities for professional development. In the spring of 1982 Joseph offered a course for teachers through Sonoma State College. The district paid Joseph's salary and provided the computer lab facility, while the university provided credit. What was exciting was that this course introduced programing without a mathematics orientation. Thus, its applications will be interdisciplinary and, it is hoped, lead to computer applications in a wide variety of content areas.

Impacts

In establishing the priorities for the computer education activities, the educators and community members in the district have had to ask: how important is computer education? As Luehrmann in his report to the district explained:

> There can be no simple answer to this question. Most people in the world have gotten along fine without knowing what a computer was, and today most educated people have never used a computer. But it was also true in Gutenberg's day (and for four centuries thereafter!) that the majority of people could not read or write. Yet by the end of the last century universal literacy had become an accepted goal of public education, and illiterates were at a distinct vocational and social disadvantage.

Luehrmann argues that those who have computer skills already enjoy several benefits: 1) vocational and professional advancement; 2) intellectual payoffs—new ways to represent or express ideas; 3) facilitation of problem solving, particularly in mathematics; and 4) a desirable skill or proficiency valued by colleges. These arguments reflect the underlying rationale for Novato's programs.

Students in the district are highly motivated in the courses and computer units. Even when visitors come into their classrooms, students ignore them, fully involved with the computer. "We can't keep the kids off the machines," stated one teacher. Novato also boasts of its computer whiz kids—students now in high schools and in their first year of college who have incredible programing skills. Some students sell programs on the side and find computer-related work in the summer. One student, Casey Kosak, has received national recognition and has been featured in an article in *Datamation*.

Problems remain, however. Keeping up with the advances in technology is one major concern. There is already a need to upgrade several of the PETs that were purchased several years ago. Officials know that new hardware may make their current inventory obsolete in a few years, but they have no easy choices, especially when funds are limited. Another area of concern is the impact that computer electives will have on other areas of the curriculum. Computer courses fill up immediately while industrial arts courses are underenrolled. Moreover, teachers cannot easily be transferred from one course area to another. To complicate matters, the options to take electives may be reduced as the school day is shortened to save money for the district. The high schools have already reduced schedules from a full 6-period day to 5½.

There is still the problem of reaching all of the student population, particularly in the high school classes. Courses are still tied to the math department, but Joseph hopes this will soon change. Finally the relationships among programs and the competition for resources causes concern. So far, "we've been able to maintain a delicate balance," says Joseph. But she worries what will happen when more schools are closed and staff positions reduced. There is also some concern that implementation of phase 3 (a second Apple lab) may be delayed, as well.

The Future

Integration of computers into the curriculum is a major objective for the future. There is already some interest among secondary teachers in English, social studies, business, foreign languages, and science. If the computer labs or clusters are used every period for computer literacy and programing courses, this may not be feasible.

There is also an interest in exploring administrative uses of microcomputers in individual schools, particularly to retrieve and handle information. Melendy expressed his concern about the disproportionate amount of time spent in looking up records, in gathering data for reports, and in other clerical tasks: "We're still working at the quill level, when we have the technology to do otherwise."

Contact and interaction with the State Department of Education and other districts in the county are increasing. The county teachers' center has become an important broker. When the State Commissioner came to Marin County in spring 1982 to focus on computers in education, he met with local district leaders and others at the center and nearby universities.

Novato elementary schools may participate in a LOGO project currently being developed by the Marin Community College, the Marin Computer Center, and the Teacher Learning Cooperative under a grant from the Buck Foundation. The Buck Foundation (administered by the San Francisco Foundation), funds are restricted to use only in Marin County. Currently several proposals for support of computing in county schools—including a mobile computer education van and a series of workshops for teachers are being examined. Joseph would like to see a Marin County symposium of national experts and local educators to measure the impact of programs. She feels it is time to reflect, to examine current programs objectively, and to identify limitations and unanswered questions. According to Joseph, "This is needed not just here, but all across the Nation."

Cupertino Union School District, Cupertino, Calif.

The Setting

Situated in California's "Silicon Valley," where apricot groves turn into computer factories overnight, the Cupertino Union School District (K-8) serves a population of 50,000. School population is 86-percent white, 8-percent Asian, 4-percent Hispanic, and 2-percent black. Although the population growth rate is one of the highest in the United States, an acute housing shortage and inflated costs have resulted in a decade of declining enrollment. Fifteen schools have been closed. The 12,150 students, half of peak enrollments in 1969, attend 4 junior high and 20 elementary schools. District boundaries cut across six municipal jurisdictions. Parents support the schools, but officials point out that only 25 percent of the area's suburban population have children in public schools.

Major industries in the area are aerospace- and computer-related. Many of the companies are small and relatively young. This is a high-tech, middle socioeconomic community with high educational expectations. There is interest from the Industry/Education Council and the Chambers of Commerce and service clubs as the schools respond to computer-related, entry-level job needs.

Cupertino has a mature, experienced teaching staff whose average age is 47. Ninety-two percent of the teachers are in the top range of the salary scale. Declining enrollments and reduced staff positions make it difficult to maintain high morale, however. Officials note that the district's staff development and incentive programs and its computer project are "our most powerful weapon" in maintaining enthusiasm and quality education.

With an annual budget of $30 million, 70 percent of funding now comes from the State, reversing almost exactly the ratio that existed before the passage of Proposition 13. Educators feel local control of education has eroded. The one benefit of declining enrollments has been the sale of excess property. Because of high land values, these sales have resulted in significant capital reserves which can be used for equipment and capital improvements only.

District Programs

Cupertino is the home of the Apple Computer Co.: "the boys that designed the Apple grew up here," relate Cupertino educators, " . . . and when they had put together their first Apple II prototype, they showed it to us." Associate Superintendent William Zachmeier and computer specialist/teacher Bobby Goodson remember the day clearly. They were amazed and excited with what they saw.

Several months later, when the district's IVC proposal for a math program to the State was turned down, Zachmeier urged Goodson to try again, but this time to try something with computers. With active support from the administration, another proposal was written. Funded by ESEA title IVC for 2 years, the junior high school project provided for a full-time director, but no equipment. In addition, IVB money was allocated to purchase three 16K Apples; old black-and-white TV monitors were located. Goodson learned by talking to people; attending meetings, and worked with students and small groups of teachers—a school at a time.

For the 2 years of the projects, says Goodson, "we felt our way around and 'nickeled and dimed' our way." Approximately three dozen computers were purchased with IVB funds, MGM State funds, and parent donations. After IVC funding ended, Goodson's position was supported by the local district. The approach was "to learn by trying out various approaches so that when we went to the board for their support of a total district program, we knew what we wanted."

In spring of 1981, the superintendent made the district proposal to place computer labs in each junior high school, and labs or clusters in half of the elementary schools, at a total expenditure of $299,337. On the night of the presentation, the board room was packed with teachers, administrators, students, and parents. "One by one they got up and told the board why they wanted computers," remembers Zachmeier. "And the board gave us everything we asked for," says Goodson.

Computer Literacy Curriculum

The computer literacy program was developed by teachers using computers in their classrooms. The program focuses first on computer awareness, and then on computer use.

The goals is that by the end of grade 6, all Cupertino students be fully "aware" of computers. By the end of grade 8, all students should have had the opportunity to use the computer as a tool and to be introduced to the idea of programing.

Inservice Training and Staff Development. The district has a long tradition of inservice. Staff can earn credit toward salary increments, in exchange for released time, for conference registration fees, for instructional supplies, or for university course work. Extensive computer inservice courses were developed and taught at first by Goodson. In time, those she trained taught others; the cadre of resource people continues to grow. The introductory course begins with three short modules of two 2-hour sessions, each followed by optional strands in programing (BASIC, PILOT, LOGO) and software evaluation and design. Courses for parent aides, secretaries, and others have also been developed.

Approximately 80 percent of the teaching staff have participated in at least one course. Moreover, all principals and administrative staff attended a 1-day workshop in the summer of 1981, led by Richard Pugh, JHS computer teacher; Judy Chamberlin, teacher of the gifted and talented; and Bobby Goodson.

Installation of the labs is to proceed in stages to provide adequate time for schoolwide planning by each faculty and for support of the program by the computer resource teacher. Three labs were completed by fall 1981. By 1982-83 all junior highs will have labs. Each computer lab will have a total of 15 student stations and a teacher demonstration station which includes a large screen TV and a printer. Two of the labs will be equipped with Apples and two will be equipped with Ataris.

All but two elementary schools have at least one computer as well, and there are at least three different systems in the schools. Diversity of hardware at the elementary school level, where computers are used in a variety of ways in classrooms and in the media centers, presents no problems. In the long run, district officials now think that this diversity will be an advantage.

Sample Programs

The computer lab at Hyde Junior High School is a large room that accommodates the student microcomputer stations comfortably around three sides of its perimeter. Small round tables cluster in the middle, where students come for discussion, instruction, and collaborative work. But most of the time it is the computers that are busy. While they input data and compose print statements, articles and pictures on the classroom walls remind them of the history of computers and where and how computers are used today. Students all seem to be working on their own assignment. While one student writes a program to calculate his grade-point average, another designs a simple game, and still another runs a preset program. Meanwhile, students at Kennedy Junior High School generate graphics on the computer, while elementary school students in the gifted and talented program at the Wilson Exploration Center develop new thinking skills using the computer, and then debug their original programs.

At Muir Elementary School, computers can be checked out to parents and teachers; every weekend they are all checked out. Because the computer in the library is used nonstop, access for many students is a problem. At the parents' insistence, two introductory workshops were offered to parents. The school plans to use parent volunteers to teach computer literacy curriculum activities during alternate library periods. In this school, parents will become a major force as volunteers in the program.

At the West Valley Elementary School one such parent, Cheryl Turner, became a catalyst and prime mover in establishing the school's computer literacy program. The program began with enthusiastic teacher and student response to Turner's demonstration of a computer she had made from a kit. With strong support from the principal, microcomputers were installed in the library media center and Turner was hired as an aide to teach computer literacy. Funding for the microcomputers came from the PTA, a grant from the INTEL Corp., and MGM funds. A parent, an Atari executive, arranged for a loan of an Atari to the school. All but two teachers want their students to participate in the program. Turner, who has "had a fascination with computers for 20 years," enjoys being a role model for the students and demonstrating, especially to the girls, "that it's okay to enjoy electronics and run around with a screwdriver in your purse."

Impacts

The computer literacy program has energized both teachers and their students. Individual parents have been tremendously supportive, although by and large Cupertino does not benefit directly from proximity to the corporate world and Silicon Valley industries.

More than 65 percent of the district's teachers have received literacy training. Goodson sees the benefits especially for those in dead-end jobs. Negative feelings have been turned around, and new life has been put into the educational process. Many are convinced that it is the opportunity to become a learner and "be in control" that is the irrestible appeal of the program.

Many students "turned off" by school have also been motivated by the program. Many are those whose interest and aptitude could not have been predicted. The problem now is getting them to go home from school.

The program has problems, but they do not appear serious. There are teachers who want to be involved in computing but who receive little support, or no access to the computers in their buildings. The inequity between some of the elementary schools continues to grow. There is also recognition that the lab arrangements do not accommodate the needs of the science teacher who wants a computer in class, nor the librarian who wants one in the library, nor the principal who wants one in the office. Additional funds may be allocated or alternate arrangements developed to serve these various needs.

Finally, until recently, there has been no integration of computing programs in the junior high school with programs offered in the high school. Students are frustrated in cases where there are no courses or when courses are outdated and equipment is obsolete.

Implications

The district goal is that all schools will have computer laboratories by 1984. Training opportunities will be expanded, and new uses for the computer in the classroom will be explored. Cupertino educators hope that there will be articulation and coordination between the secondary school systems.

Beyond the new courses and expanded efforts at the secondary level, Associate Superintendent Zachmeier's ultimate goal is to give every youngster a computer some time in elementary school because:

> There will be a need for new skills and new attitudes. It's our job to prepare students for the kind of world that will become *not* the world that was. We will have kids who leave Cupertino . . . who will be fully computer-literate, discriminating buyers and users. And rather than being prisoners of technology, they will be masters of it.

Resources

Persons interviewed:

Novato Unified School District, Novato, Calif.

Helen Joseph, Computer Resource Teacher and Coordinator
Ronald E. Franklin, Superintendent
Richard Melendy, Principal
Jack O. Rothe, Director of Instruction
Arthur Luehrmann, Former Director, Computer Project, Lawrence Hall of Science
Joyce Hakansson, Former Education Program Coordinator, Lawrence Hall of Science

Cupertino Union School District, Cupertino, Calif.

William Zachmeier, Associate Superintendent
Jerry Prizant, Coordinator of Media Services
Bobby Goodson, Teacher, Hyde Junior High School, Computer Literacy Lab and Coordinator, Computer Programs
Frank Clark, Principal, Kennedy Junior High School
Richard Pugh, Teacher, Computer Literacy Lab
Ron LaMar, Principal, Hyde Junior High School
Harvey Barnett, Principal, West Valley Elementary School
Cheryl Turner, Aide, West Valley Elementary School
K. A. Fisk, Principal, Muir Elementary School
Judy Chamberlin, Teacher, Gifted and Talented Program Wilson Center

Computer-Using Educators - CUE Monthly Board Meeting, Palo Alto, Calif., Jan. 22, 1982.

Bobby Goodson, President, CUE, and computer resource specialist Cupertino Union School District
Jose Gutierez, Vice President, CUE, and faculty member, San Francisco State University
Ann Lathrop, library coordinator, San Mateo County Board of Education
Helen Joseph, resource teacher—math, science, and computers, Novato Unified School District
William Sandy Wagner, computer coordinator, Santa Clara County
Glenn Fisher, computer coordinator, Alameda County
Le Roy Finkel, computer coordinator, San Mateo Office of Education
Karen Kent, director, Teachers Learning Cooperative, Marin County Office of Education
Don McKell, teacher, Independence High School, San Jose
Brian Sakai, computer teacher, San Carlos High School
Russ Bailey, computer district coordinator, San Mateo City Schools
Bob Enenstein, teacher, Carlmont High School, Belmont
Steve King, computer teacher, Crittendon Middle School, Mountain View

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*These first activities provided access to students in the Junior High School GATE program and were supported by State MGM (mentally gifted minor) funds.

*As more equipment is purchased, the district will shift hardware to have uniform equipment in the junior high labs, where programing is taught.

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Technology Education and Training, Oxford Public Schools, Oxford, Mass.

Introduction

The technology training and education programs of the Oxford Public Schools were selected for study because they provide an example of how a small, rural school district with limited local funding resources can offer up-to-date education and training opportunities to its students and adults in the community through partnerships with private industry and other rural school districts. This study also provides an example of the impact of Federal and State grants on the implementation of new programs. Although each grant was relatively small, "to Oxford they looked like a Hope Diamond," according to the Superintendent.

The Setting

Originally a French Huguenot settlement, Oxford was founded more than 300 years ago in central Massachusetts, approximately 20 miles south of Worcester. Once the center of a thriving mill industry, Oxford's economic base seriously declined as the mills closed. At present only one small mill operates; it employs five people. No new industries have been established. Oxford's population of 11,450 is primarily blue-collar. In 1980, Oxford's annual per capita income was $6,582. Of the adult working population living in Oxford and surrounding similar communities, 60 percent are semiskilled or unskilled workers and 11 percent hold professional or managerial positions.

A special program at the Oxford High School District introduces students to the world of computer maintenance and electronics fabrication. This student credits her graduation from Oxford High School to the engaging qualities of the curriculum, which, she said, kept her in school after she had become disenchanted with the regular academic program

The Oxford Public Schools serve 2,460 students in grades K-12 who attend three elementary, one middle, and one high school. Almost all students are white; fewer than 1 percent are black, and fewer than 1 percent Hispanic. Of the high school graduates, 30 percent attend 4-year colleges, while another 30 percent go on to community college and vocational training institutes.

In this rural community, according to its superintendent, there is strong support for education with local taxes, although Proposition 2½ now limits that revenue source. The 1981-82 budget of $4.2 million results in an expenditure of $1,945 per pupil. Many of the teachers are from the local or neighboring areas, and there are common bonds between the educators and the school board. Even with declining resources, administrators and teachers feel that there is support from the board and community and that their efforts in behalf of the students are appreciated.

Building New Partnerships to Link Education and Technology Training

History. Francis Driscoll, superintendent of this small, rural school district with almost no local industrial base, searched for ways to meet his students' diverse needs. Although the district was small, it had students who could not function in regular classrooms because of emotional and learning handicaps, whose abilities were seriously underchallenged, and whose interests weren't being met. The solution he developed, late in the 1970's, was to form a loose federation of similar districts near Oxford, to develop programs that they all needed.

Driscoll reasoned that by regionalizing programs and services through the federation and other similar cooperative efforts, he could create the equivalent of a small-sized city and the critical mass needed. By joining Oxford to Auburn, Leicester, Charlton, Dudley, Webster, and then Southbridge, the combined federation involved 35,000 students, 1,200 teachers, and 62 members of local boards of education.

The Oxford School Board and administration agreed that they would serve as fiscal agents for any cooperative projects. Proposals were developed and funded. One Project—COFFEE (Cooperative Federation for Educational Experiences)—provided occupational training and education for students with special needs, and was funded by the Massachusetts State Department of Education in 1979. A second proposal for a regional teacher training consortium, the French River Teacher Center, was funded by the U.S. Department of Education from 1978 to 1981. Both projects are housed in Oxford, with COFFEE in a portable building next to the high school. The teacher center was built from surplus motel shells, moved to school land, and assembled and finished with professional contractors and students from the vocational training programs.

As district educators looked at the State's burgeoning high-technology industries and the growing relationship between education and training, it was clear to them that high technology was not just for elite students. Informal data gathered from Worcester and Boston area industries revealed that entry-level high-tech jobs were underfilled and that 80 percent of those jobs did not require college training. It was also clear that partnerships with private industry had to be developed.

John Philippo, the program director of Project COFFEE, and Rob Richardson, the director of the French River Teacher Center, became involved with the local industry councils and the State High Technology Commission. Serving on committees and attending meetings, they made direct contacts with individuals from electronics and computer industries located in the Worcester and Boston areas.

Mike Odom, DEC Executive on loan to the Humphrey Occupational Center, notes that the Oxford educators were unusual—"they sought our advice, and they listened." Similarly, the superintendent proposed to the school board that the district develop a working relationship between education and industry. The school board, remembers Chairman Schur, said, "Go ahead, you have our blessing."

The district efforts focused on computer technology, an area that both the special needs training program and the teachers were interested in. Eventually, several paths led to one of Massachusetts' largest computer corporations, Digital Equipment Co. (DEC). Early contacts were with salespersonnel and then, Mary Ann Burek of the Corporate Contribution Division, who put the district in touch with Del Lippert, Corporate Manager of Educational Services.

Current Programs

Project COFFEE. COFFEE is an alternative occupational education program for the special-needs, disadvantaged, and handicapped students of a six-community cooperative school federation. The program includes life-coping skills education, as well as an occupational educational experience in an adult-like work environment. The high-technology training components provide the student with job entry skills, job placement skills, cooperative job experiences, shadowing experiences (job observation), and a related work study program.

In the electronic assembly component, students read and interpret schematic diagrams and mechanical drawings and gain experiences in layout, manufacturing, and assembly of printed circuits and electronic components. Students test and inspect electronic components, circuits, and assemblies. They are trained for entry-level employment as: electromechanical assemblers, electronic maintenance workers, drafting assistants (electronics), electronics utility workers, electronics inspectors, electronics mechanics, electronic testers, and electronics assemblers. Many of the assembly tools and testing devices and most of the hardware, components, and circuitry used for hands-on instruction was donated to the program as a result of individual, personal contacts with electronics companies.

After a year of operation, the Project COFFEE director, John Phillipo, and Superintendent Driscoll planned a new component that would involve use of state-of-the-art computer hardware. Contacts with DEC were made, and the company contributed $22,800. In the data-processing component, started in September 1980, students use state-of-the-art computer hardware and software techniques in the computer center and an automated office. The instructor assumes the role of data-processing manager, and students learn by hands-on experience in hardware operation and maintenance, computer awareness, and use of BASIC. They are trained for entry-level employment as junior programers, console operators, computer service technicians, data typists, printer operators, control clerks, and computer aides.

Project COFFEE was funded through a statewide competitive grant process utilizing Federal occupational education and special education moneys authorized under Public Laws 94-482 and 94-142, a total of $557,402 for September 1, 1979, through June 30, 1982. In cost breakdowns by program areas, a total of $167,050 was expended for the two technology components for more than 100 students over the 3 years. The students in these high-technology components use facilities in the Oxford district, while students in the distributive education component run and operate The Grand Illusion Printing Co. in Auburn, and students in the buildings and grounds component work in Webster. The program is continuing tenuously on local support, but long-term commitments have not yet been obtained.

Project KING-By Tech. In the fall of 1980, the Governor of Massachusetts created the Bay State Skills Commission to fund projects that would address the needs of the State's computer industries for trained workers. Superintendent Driscoll formed a planning group that involved local educators and representatives from industry, colleges, the French River Teacher Center, the Worcester Chamber of Commerce's Career Education Consortium, and the Central Region Private Industry Council. The key to funding was the stipulation that 50 percent of financial support come from private industry and that the other 50 percent be available from the Skills Commission.

Late in the fall, Driscoll initiated direct contact with Del Lippert, Corporate Manager of Educational Training and Services at DEC's headquarters in Bedford. Recounts Lippert: "Driscoll had an idea and the Governor had a half million in discretionary funds." It was, according to many in Oxford, "a meeting of kindred spirits—both want to make things better for education."

Project KING-By Tech (Key Industrial Needs Gapped by Technology) was funded in January 1981 to provide underemployed and unemployed adults training opportunities in word processing, office automation, electronic assembly, programing, and program application. A total of 110 students were served with $46,015 from the Bay State Skill's Commission, $43,015 from DEC, and $3,000 from Quinsigamond Community College for instructors. As a result, the district's inventory of computer center hardware was increased, two teachers received training from DEC, and the working relationship with DEC was well established. DEC's Lippert explained that his company was interested in working with schools "who want to work with us, want to make something happen." In the case of Oxford, there was a sense that the social and manpower views of the district tied into those of the company. Furthermore, Lippert felt that Driscoll conveyed a commitment and enthusiasm that was unique.

French River Teachers Center. Through the French River Teacher Center, 30 guidance counselors from Central Massachusetts high schools are learning about high-technology career opportunities (Project CHANCE). Sixteen sessions (begun in January 1982) included field trips to computer companies and companies that use high-tech tools, as well as discussion forums with representatives from nearby industries. Audiovisual, self-instructional materials on technology career donated by DEC will also be used. This project grew out of activities with the high-technology industry representatives from Unitrode in Lexington, Prime Computer in Natick, and Micro Networks in Worcester.

The Teacher Center, federally funded through September 1981, has continued to operate with a director and a part-time secretary. Its continued existence depends on the director's ability to broker new relationships, such as the counselor's project and other activities with the district's technology and training-related programs. For example, in February 1981, again through occupational education moneys, the Teacher Center provided training for 30 surplus teachers and other unemployed adults in computer programing (COBOL), word processing, and electronic test technology and assembly. The $54,080 project received $39,742 from the State, $8,640 from DEC, and $5,698 in contributions from the district. Several teachers trained in the program were able to find new jobs in the industry.

A mobile computer bus with $100,000 worth of equipment was loaned to the French River Teacher Center for use by area teachers and students in the spring of 1982. The bus was equipped with a PDP 11-34A computer and two video terminals, one magnetic tape card reader, two hard-copy terminals, and several self-paced instructional stations. Owned by DEC, the bus had previously been operated by the Commonwealth Center in Cambridge.

The Teacher Center will share use of the bus with the Humphrey Occupational Resource Center in Boston. Present plans are to find minimal funding so that a technician can take the bus from school to school, giving youngsters the opportunity to have hands-on experience. The loan of the bus was first discussed during a 1-day teacher center seminar on computer technology held December 8, 1980, and attended by representatives of 11 school districts, 3 colleges, and private industry. A loose "consortium of computer teachers" was formed and has met several times.

The center has arranged for teacher workshops and courses on computers and microcomputers, collaborating with the Commonwealth Inservice Institute (funded by an IVC grant through the Massachusetts State Department of Education). Area teachers have learned BASIC programing languages, explored a variety of software applications, and examined computer applications and impacts. The center also organized a technology conference with the New England Teachers' Center Cluster, held this May in Worcester. Director Rob Richardson's contacts with DEC and other high-tech industries will enable him to schedule field trips, speakers, and presentations.

Impacts

Impacts on the School System. As far as principal Roger Bacon is concerned, the benefits outweigh the problems. The district has equipment worth a half million dollars that could not have been obtained any other way (see table A-1). Furthermore this state-of-the-art hardware is supported by DEC training and software. The two Oxford teachers trained at DEC have acquired the most current information and skills, and they immediately draw on these skills in working with their students. The collaborative partnership with industry goes far beyond the benefits received thus far. It is clear to Oxford's superintendent and his technology teachers that this working relationship is critical in enabling the district to keep up with the rapid changes in high technology.

Furthermore, DEC's expertise is recognized and relied on as program additions or revisions are considered. Other nearby companies directly concerned with the high-technology training programs are also continually contacted and utilized as resources. These close ties to industry, argue Oxford educators, make their programs more effective and unique.

Impacts on Teachers. Through the French River Teacher Center, Oxford teachers and those of the surrounding districts have participated in workshops, forums, courses, and visits to high-tech companies. Although no formal assessment of these efforts has been made, teachers indicate that they are better informed, more comfortable with technology, and would like to have more opportunities for training.

Impacts on Students. The Federal and State funded programs have reached numerous students. Project COFFEE students recognize that they now have skills, and they feel good about themselves and their program:

> . . . I'm an electronic assembler, I *have* a trade. . . . I can build you a stereo; before, I only knew how to push the buttons. . . . There are regular kids (taking the electronics assembly course) . . . and they need our help. They can't do the things we can. . . . If the program wasn't here, I'd be out of school . . . we have teachers who understand us.

In assessments of student progress in entry-level high-technology training skills, based on a series of competency tests developed by the project staff and 16 industry/business representatives, 82 percent passed electronic assembly and 77 percent passed computer technology. The success of these special students is related to many factors. Technology skills, special counseling, and basic educational programs have all played a part. For the high school principal, the important result is that these students are turned around: "When these seniors graduate this spring and I get to shake their hands . . . I feel that this is what education is all about."

In addition to the COFFEE students, other students from Oxford High School have also made significant gains in computer programing courses and in independent study projects under the direc-

Table A-1.—Sources of Funds for Computer Hardware and Software, 1980-81

Description	Direct market value	Digital Equipment Corp.	State/Federal grants	Oxford School Department	Total
1 PDP 11/34 central processing unit	$41,500.00				
1 16-line multiplexor	4,100.00				
2 LA 34 decwriters	2,900.00				
1 285 LPM printer	7,800.00	$23,530.00	$39,097.00	-0-	$62,627.00
1 VT 100 video terminal	2,050.00				
3 modem cables	177.00				
1 200 CPM card reader	4,100.00				
Systems management training	2,100.00	2,100.00	-0-	-0-	2,100.00
Data-processing renovation/installation	9,150.00	3,000.00	6,150.00	-0-	9,150.00
3 W3 78 word-processing units	28,500.00	14,250.00	1,250.00	-0-	28,500.00
			13,000.00		
Electronics assembly training	3,200.00	3,085.00	115.00	-0-	3,200.00
1 TS-11 tape drive	15,400.00		2,035.00		
3 VT-100 video terminals	6,150.00	13,325.00	7,000.00		26,650.00
3 LA 34 decwriters	5,100.00	4,290.00			
1 LA 34 decwriter	1,700.00		8,292.00	-0-	16,786.00
4 VT 100 video terminals	8,200.00		-0-		
1 RL02 disk drive	5,911.00	8,494.00			
5 RL02 disk cartridges	975.00				
14 self-paced audiovisual instructional programs	15,320.00	15,320.00	-0-	-0-	15,320.00
94 hours, level I consultants	5,160.00	2,560.00	2,000.00	-0-	5,160.00
Instructional supplies	14,130.00	3,150.00	600.00		
			4,200.00		14,130.00
			4,830.00		
			1,950.00		
Software programs	81,000.00	52,000.00	29,000.00	-0-	81,000.00
Totals	$264,623.00	$145,104.00	$119,519.00	-0-	$264,623.00

SOURCE: Oxford Public Schools, Oxford, Mass.

tion of the computer center director, Al Jones. "In this kind of an environment, you don't have to push them, you just have to keep up with them . . . The interest, the turn-around, the growth, of these youngsters is incredible."

As in many other districts, these computer whiz kids are at the center early in the morning and late in the evening until Jones locks the door. Several students—presently three or four—will have the equivalent of 2 years of college-level computing when they graduate high school. Another 30 or 40 will have 2 years of programing experience, not just in BASIC, but also in Pascal and in WATBOL (the University of Waterloo, Canada, educational version of COBOL). Students learn to operate all phases of the system, and their understanding and experiences are intentionally geared to the real world.

Jones talks about one of his students, a junior, who has written a "wonderfully sophisticated program to chart and analyze students' chronobiological rhythms." Jones says this program "is better than the $20,000 software package we bought for principals." Another student recently went to help a nearby school district that was having major problems with its DEC system. In 3 hours he had solved many of the problems.

Only a few problems remain. One is that, on occasion, security of school records is a problem because both instruction and management functions are together. Also, there is a growing demand for courses and computer access, and demand may outpace resources. Finally, there are some who question the district's growing emphasis on technology and programs for special students. They worry that other areas will be shortchanged.

Impacts on the Community. According to school board members, parents and students say again and again, "What a difference the technology programs have made." Parents describe changes in their children and indicate that they are now interested, know what they want to do with their lives, and have made complete turnarounds. What appears to be most important to the community is that these students have goals and some have employable skills. High school principal, Bacon explains: "They (parents and students) know that computers are the 'in' thing in Massachusetts."

By extending the technology programs to underemployed and unemployed adults and surplus teachers, the schools have made maximum use of the computer center and have provided benefits to the community. The absence of continuing financial support, however, may limit the long-term.

When the community parents, school board members, teachers, and administrators are asked why it has been possible to bring technology training and education to Oxford, they point to the following:

- an aggressive, energetic superintendent willing to chart unknown waters and take risks in starting programs without the security of long-term funding;
- a willingness by the school board and the administration to serve as the fiscal agents for the projects: to write the proposals; to negotiate with State and Federal funding agencies; and to contact the private sector;
- the commitment and ability to work together —administration, professional staff, school board, other districts, the private sector—to "get what we need for our students;"
- the availability of Federal and State funds, without which none of the programs could have been initiated;
- an ability to find resources when they aren't there: assembling a teacher center from surplus concrete motel shells transported to the site; or scavenging cartons of printout paper used on only one side, which become perfectly appropriate for the student's output; or scrounging obsolete electronic equipment, which became the instructional cadavers in the assembly labs;
- the use of professionally supervised students to reduce building assembly and finishing costs and, at the same time, meet the student need for on-the-job training; and
- a belief that "everything we do can lead to something else."

Finally, they single out the superintendent's leadership and skill in unifying all of the participants, forging private sector partnerships on a personal one-to-one basis, convincing State officials from various departments to fund programs jointly, and utilizing public schools and community college facilities to expand technical educational opportunities.

Future

How will programs that have been developed continue to be supported? "Will the benefits and the progress made . . . that we are so proud of . . . now be emasculated because of financial constraints?" worries the school board chairman. With increasing costs, a reduced budget from Proposition 2½, and fewer Federal dollars for education, school officials and the community are concerned. There is some hope that the maintenance costs for these programs will be lower than the startup costs. Furthermore, it is hoped that the other districts will be able to find a way to pick up local costs.

Finally, Oxford has submitted Project COFFEE for validation by the Joint Dissemination Review Board of the U.S. Department of Education so that the Project could be eligible for National Diffusion Network Funding. Superintendent Driscoll hasn't given up on the State Department of Education, either.

Then there is further collaboration with the private sector. Educators argue that turning out trained, qualified people is the best selling point they have. The industry needs their graduates. When Project COFFEE students completed the wiring for the computer center, they proved they were capable of technically demanding work, and they saved the district $2,000.

Driscoll's dream for his schools and for his community goes even further. He wants to bring a major high-technology company manufacturing plant to Oxford. He feels this would strengthen the town's economic base and provide the long-term support the educational system needs. Others in the community support this idea and are hopeful that the district's technology training programs will be a strong selling point.

Resources

Case study interviews:
Francis G. Driscoll, Superintendent
Roger Bacon, Principal, Oxford High School
John Phillipo, Director. Project COFFEE
Allen Jones, Director, Computer Center and Teacher
Rob Richardson, Director, French River Teacher Center
Pat Ferreira, former teacher, Oxford High School
Elaine Birchard, student
Gary Bigelow, student
Paul Winiarski, student
Kenny Gatze, student
Walter Schur, Chairman, School Board
Patricia Troy, School Board Member
Del Lippert, Corporate Manager, Educational Services, Digital Equipment Co., Bedford, Mass.
Michael Odom, Digital Equipment Co., Executive-on-Loan, Humphrey Occupational Center, Boston

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Computer Literacy Program: Lyons Township Secondary School District, LaGrange, Ill.

Lyons Township's computer program was selected for study because it exemplifies a systemwide application of computing that involves and affects the district's entire student population and more than 90 percent of the district's professional staff in all curricular areas. This site provides an example of how a major infusion of computer hardware facilitates its widespread use and within a school system access. Local funds support the purchase of hardware, training of teachers, and development of software. Furthermore, it shows the critical role played by the local superintendent in conceptualizing the program, initiating action, and supporting ongoing activities.

The Setting

Located in the southwest suburbs of Chicago, the two campuses of the Lyons Township High School's (LTHS)—in LaGrange and Western Springs—enroll a total of 4,000 students. The school population is drawn from six suburban areas that are primarily middle-class, bedroom communities of Chicago. Approximately 90 percent of the students are white; 3 to 4 percent are black; 3 to 4 percent are Asian; and 4 percent are Hispanic. The majority, 75 to 80 percent, of LTHS graduates go on to college.

The school district's financial base is stable. Local property tax revenues (which include a strong industrial base) account for 85 percent of the budget; the remaining funds come from the State. The current budget is $19 million; per pupil expenditure is $2,300. School buildings are well-maintained—offices, hallways, and classrooms are pleasant and clean. Facilities appear to be more than adequate. (The boardroom looked more like that of a major corporation than of a school district.)

There is general consensus among the educational and lay communities that the district has been well, but conservatively, managed to support a strong, traditional curriculum. Through prudent management over the past dozen or so years, substantial sums have been placed in reserves—a unique situation, considering the strained economic condition of most of the Nation's schools.

Declining enrollments, the major area of concern for the district, may eventually have a negative affect on the number of facilities used (one or two campuses), the variety of programs offered, and the size of the professional staff. However, the superintendent argues that these problems can be resolved, in part, by the district's effective use of technology.

On the whole, the district's problems appear minor in comparison with other districts' financial woes, population shifts, student unrest, and staff reductions. Administrative and teaching staff and board members acknowledge how fortunate the district is. For example, teachers' salaries are at the top of national pay scales, and a new 3-year contract is in place. The major focus of the students and faculty is education, where learning is viewed as a serious endeavor.

Computer Applications in the District

The district's use of computers goes back to the late 1960's, when its first mainframe computer was purchased for the district's management and business operations. As in other districts, instructional opportunities for students were limited to a few highly specialized courses in the business and math departments. Approximately 2 years ago, it became apparent that the district's computer was outdated and would need to be replaced. In addition, there was a growing interest in expanding instructional computing activities and a general feeling that computer literacy was important. The initial approach, according to a member of the school board, was to expand the large computer system to accommodate both needs.

At the same time, the board was interviewing prospective candidates for superintendent. John Bristol was the board's choice, in part because he already had experience with computers and instructional applications and had started one of the earliest computer literacy programs in Minnesota. Bristol convinced the board that student uses of computers ought to be considered separately, and that microcomputers provided a viable option to a mainframe computer with terminals. With strong support from the board, Bristol came to LaGrange ready to revise and expand the district's computer programs.

Planning

The superintendent's first objective was to develop a plan. From the outset, all the curriculum areas were involved. Decisionmaking was not limited to computer experts; building principals, department chairmen, and interested teachers were involved. A basic assumption of the plan was to provide computer experiences for all students: "the use of the computer should not be reserved for the gifted and/or mathematically oriented student. The computer needs to and can be utilized by students of all ability levels, including those with limited learning capabilities." Three major applications were designated:

Instruction
Literacy
Competency
Speciality
Instructional support
Tutorial work
Drill and practice
Problem solving
Simulation
Instructional games
Instructional management
Success prediction
Monitoring student progress
Vocational guidance
College information

Hardware Selection

Another component of the planning activities was the selection of hardware. Not surprisingly, the most important criterion was "to obtain the maximum number of microcomputers for the dollars available." Local maintenance and repair capability of the hardware vendor was also important. The planners agreed that highly sophisticated microcomputers with sound and color capabilities were not needed for this initial phase (computer literacy). However, networking capability was considered highly desirable and, networking in the laborabory setting is envisioned.

Hardware for the laboratories use a networked Radio Shack TRS-80, Model III Configuration: one 48K, twin-disk microcomputer, 26 16K, tape microcomputers, two networks, and one printer. Eight laboratories—four in each campus of the high school—are installed, with a total of 208 terminals for student use. The cost breakdown over a 5-year period is shown in table A-2. The superintendent maintains that these costs are reasonable.

In an interview with the *Chicago Tribune*,[1] Superintendent Bristol justified the district's large purchase:

> Some schools are reluctant to buy (microcomputers). They say that tomorrow there will be a faster or cheaper model. But how many tomorrows do you wait for? What is the value to get our students to have computer literacy *now*?

Computer Literacy for All Students

With the installation of over 200 microcomputers in eight laboratory settings, students at Lyons Township High School interact with technology first-hand. During the school day, the laboratories are busy with students and their teachers in a variety of subject areas. *English* students are refining their understanding of paragraphing with a tutorial program; *consumer education* students develop budgets using the number-handling capabilities of the computer; juniors in *social studies* master the facts required by the statewide constitution test in a series of drill and practice exercises; *biology* students solve problems using the computer as a powerful tool for analysis; and *special education* students expand their world history vocabulary in a series of drills, with opportunity for extended practice with an infinitely patient teacher.

Table A-2.—Five-Year Breakdown of Computer Hardware Costs

	Each	Total
Hardware (Networked Radio-Shack TRS-80, Model III)		
1 48K, twin disk	$1,946.10	$1,946.10
26 16K, tape	779.22	20,259.72
2 networks	389.22	778.44
1 printer	904.80	904.80
Total per classroom		$23,889.06
Total for 8 classrooms	× 8 =	$191,112.48
Cost extension		
5-year life		
400 students per year		
Cost per student for literacy per year		
(Total cost ÷ 5 years ÷ (4,000 students + 4,000)		
$191,112.48 ÷ 5 ÷ 8,000 = $4.78/student/year		

SOURCE: Lyons Township Secondary School District.

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[1] *Chicago Tribune*, Sunday, June 7, 1981.

These computer-related activities are part of the program aimed at schoolwide computer literacy. In increasing numbers, students use the terminals before and after school. According to Bristol:

> My computers are used all the time. It's the best-used activity I have. To think that we were nowhere last spring and (look at) where we are today, I would have to say we've made a significant step forward.

A further step was taken in the spring of 1982, when all students completed a 5-hour "literacy package" that included lectures, films, group discussions, and hands-on activities. The package: 1) provided information about how computers work; 2) promoted keyboard familiarity; 3) promoted knowledge of BASIC language components; 4) facilitated programing activities; and 5) focused on future technology developments and their impacts on society. Current plans are to implement this package during second-period classes —1 day a week for 5 weeks, on a staggered schedule—thereby reaching all students with minimal disruption of ongoing classes.

The subject area applications and the special 5-hour computer literacy package were based on curriculum objectives originally developed by the Minnesota Educational Computing Consortium and adapted by the Lyons Township teachers to fit local needs.

Other Computer Applications

Six different computer specialty courses are now offered through business education and mathematics. These courses include data processing, programing languages (BASIC, COBOL, RPG), and systems analysis. Approximately 10 students complete the entire range of courses. However, within the last year, an extra section of the introductory BASIC course was added to the north campus schedule, and two additional sections were added to the south campus schedule. According to one of the computer course teachers in business education, there is a "growing interest from one semester to the next . . . that is a result of the literacy program."

Teacher Training and Staff Development

The goal of computer literacy for all students and the objective of providing hands-on experience with computers in all subject areas made systemwide teacher training not only desirable but absolutely essential. Since the district could not count on hiring new staff, particularly as enrollments continued to decline, the superintendent's strategy was to reach out to all faculty members to build their awareness of the potential for computers in education, to cultivate their support for the program by involving them in the planning of workshops and computer software curricula, and to develop their computer literacy through training workshops and other staff development activities.

Costs for most inservice training activities (e.g., substitutes, consultants, payment for additional working hours) were absorbed by the district's operating budget. A separate allocation for the summer software development activities was approved by the school board. By relying primarily on local district resources and scheduling activities during school hours, the district reduced training costs. At the same time, this approach widened the base of support and ensured districtwide commitment to implementation of the computer applications.

According to Esther Gahala, director of curriculum, there appeared to be a strong sense of learning by doing; the staff response was largely positive. Participation in the 8-hour fall workshops was voluntary, although some staff felt pressure from the administration. Gahala felt: "the value of these (staff development activities) was in finding out what not to do with teachers and students as well as what to do. Each experience refined our judgment and helped us in planning the next phase." Even more important to Gahala—who points out that she was unprepared to and, at first, totally overwhelmed by the thought of implementing computers in education—was the emergence of a cadre of 45 to 50 teachers who could advise, evaluate, and be a strong support system for the rest of the faculty.

Software Development

It is not clear whether software development was part of the superintendent's original plan. However, once the curriculum committee and advisory groups examined available software, there was a growing consensus that the district would need to develop its own. Proposals for computer applications were solicited and 47 proposals from 16 departments were accepted. Among the proposals were:

- Reinforce the spelling of words English teachers believe all students should know.
- Test the effects of alcohol on parts of the body, using statistical information, for a health course unit on alcohol abuse.
- Determine the gross national product of a country after being given certain characteristics.

- Drill basic chord fingering for learning how to play the guitar.
- Recognize grammatical errors in sentences for an English course.
- Determine appropriate calorie intake based on individual physical characteristics, physical activity, and weight goals for a unit on nutrition in a home economics course.

The superintendent wanted to involve teachers in the ongoing development process and, at the same time, use computer programers to write the software. To bridge the gap between the teacher-authors and the programers, the superintendent selected teacher-consultants from the staff who had both curriculum and programing expertise to function as supervisors. These supervisors played a pivotal role in software development by helping teachers understand how their teaching ideas could be translated into interactive computer formats and by helping programers design routines that were educationally sound.

Over the summer three software development teams (fig. A-1) produced more than 108 different program packets at a cost of $87,000. Originally, Bristol projected that 60 packages would be completed at a maximum total cost of $90,000. By hiring three local college student computer science majors as programers, the district used local resources and paid them at a rate of $10 per hour. However, without the expertise of the three teacher-supervisors (one of the three was described as a computer genius, able to solve problems and make the programs run for even the most novice user), the efficiency of the programers might have been reduced.

Impacts

It may be too early to assess the impact of the recent computer-related activities in the Lyons Township Secondary School District. However, there is evidence to suggest that both students and teachers have benefited.

Access to Computers

Students in this district do have opportunities to use computers during their regularly scheduled class time and before and after school. Some students interviewed carry their own floppy disks with their books from class to class. Some of the disks contain games; others hold student programs and ongoing projects. The district does not yet have data on the number of computer-related activities completed by students. However, it can be reasonably assumed that these students are interacting with the technology far more than students in other high schools where the number of terminals is far less.

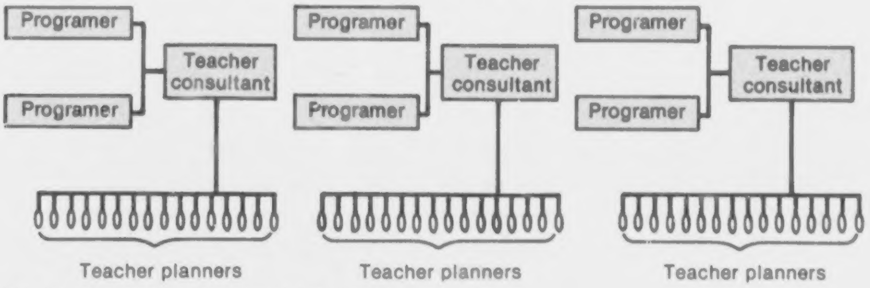
Teachers in the district also appear to have significantly more access to computers. Several teachers indicated that they regularly work with the computers on their own time. Some even take microcomputers home over the weekend.

Interest and Motivation

There is ample evidence to conclude that teachers and students alike have been stimulated by the programs. A student reflected: "I was here this summer . . . and teachers were asking—are the computers here today? Each day (the teachers) were learning new things. It really got me geared up—excited about the computer course this fall." An unanticipated benefit has been the opportunity for both students and their teachers to share learning experiences.

Teachers comment repeatedly about the intrinsic motivation of the computer. Some applications are more interesting and effective than others. The

Figure A-1.—Software Development Model



SOURCE: Lyons Township Secondary School District, La Grange, Ill degree of meaningful interaction is a key factor, according to Julie McGee, an English teacher. To maintain student interest, programs must be cleverly and creatively designed, "we can't just put our lecture notes on the computer." All indications suggest that interest and enthusiasm will continue. However, cautions a student, not all students react the same way: "too much review and testing, large amounts of text (sic too much writing, not enough graphics), mandatory classes may turn the kids off." For the teachers, "time, money, experience, vision" and a willingness on the part of the administration to revise plans to fit needs will be critical.

Curriculum and Instruction. So far, impacts on the curriculum have been limited to computer literacy activities. The strategy of building applications into existing courses appears to be working. One problem, however, is the uneven development of software. Some subjects have many applications (English, home economics) while others have only a few. Drill and practice formats predominate. Only a few simulations and tutorials exist.

Instructional effectiveness of the computer packages and related activities has not been formally assessed. As students and their teachers use the materials, they indicate that most are working. According to the director of curriculum, "we have the overwhelming feeling that what we are doing is worthwhile." However, there is a need to analyze the appropriateness and effectiveness of the materials, not only to improve them, but also to move ahead.

Some questions remain: Are the students learning skills and content more effectively? Will all second-period teachers adequately cover the computer literacy activities? Do the activities result in student comfort and skill with computers? Is the computer's potential being realized? How well do computer programing courses mesh with postsecondary academic programs and vocational training? There is some frustration over not being able to tackle all of these questions at once.

Professional Growth and Development

Estimates vary on the extent to which Lyons Township High School teachers have become computer-literate. For many, the workshops introduced a welcomed new skill. For others, the groups were too large, the keyboard and computers were too alien, and the fear of failure was a barrier. Continued meetings and support activities have gotten and kept many teachers involved, but a few holdouts remain.

On the whole there is ample evidence to suggest that the majority of the high school faculty has strongly supported the program. Direct involvement of teachers in planning, training, and software development resulted in strong feelings of pride and ownership. The district's strong support of professional development appears to be paying off: 108 software packages are in use; new ideas are continually being developed; and many teachers are expanding computer knowledge and expertise on their own time—taking courses, learning from more knowledgeable colleagues, and teaching themselves. Opportunities for new role as teacher-programers are invigorating and rejuvenating this mature, highly experienced faculty.

The Future

In the immediate future, the superintendent and his staff expect to implement the computer literacy program fully. At summer's end, all students will have taken the 5-hour course, and the remaining software packages will have been completed.

The next steps will focus on developing a comprehensive plan for computer competency and specialization. Full integration of the computer for computer-assisted and computer-managed instruction is expected within the next 5 years. The latter will depend on continued local software development and the availability of commercial courseware. In addition, with the major infusion of hardware, a corps of teacher experts, and an on-going program, the superintendent believes the district is ready for research and development. The opportunities for working collaboratively with hardware vendors, software publishers, university researchers, and other districts are beginning to be explored. There are tentative plans to hold a software development conference involving educators and developers statewide, perhaps nationwide. Plans already exist to field test new hardware components for the Radio Shack computers.

At the heart of future plans are the teachers and staff in the district. Bristol is convinced that the full potential for retraining, for new roles, and for continued purposeful activity has barely been tapped. It is likely that funds for continued staff development and for computer activities will be available as long as the school board, community, and educators support the various computer activities.

Resources

Case study interviews:
John Bristol, Superintendent
Esther Gahala, Director of Curriculum and Instruction
Julie McGee, English Teacher
John Gentry, Business Education Teacher
Bill Mchalski, student
Janet Kaski, student
Mark Nelly, student
Kim Firestone, student
Tric Coates, student
Doug Hammer, student
Jean Donnelly, President of the School Board

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Minnesota Schools and the Minnesota Educational Computing Consortium

The decision to visit selected Minnesota schools and focus on the activities and impact of the Minnesota Educational Computing Consortium (MECC) was based on evidence that Minnesota leads the Nation in computing activities in its educational system. This case study deals with a State education agency that provides a centralized system for computing and support services. With a computer inventory of approximately $44 million[1] and estimates that 1 to 1½ percent of annual school budgets will be used for hardware purchases, Minnesota classrooms are expected to have 10,000 instructional computing stations by 1984.

The Setting

Minnesota is the "Land of 10,000 lakes," and almost as many computers. Most of the State is rural. Fifty percent of the its population of 3,804 971 is concentrated in the Twin Cities of Minneapolis and St. Paul. There are 437 school districts and a median district size of 722 students. Major industries are agriculture, mining, and computer-related technologies.

Minnesota has provided strong support for public elementary, secondary, vocational, and higher education. Its education budget has one of the highest per capita education expenditures in the Midwest. This support has been matched with a commitment to innovation and educational improvement. Over the last decade, the State has provided funding through the Council on Quality Education (CQE) and title IVC Federal moneys for research and development of instructional computing applications. Projects have focused on instruction in all subjects, as well as piloted new ways to deliver instruction. Projects such as the Hopkins computer-assisted management system, the computer learning center in Littlefork, and the Robbinsdale computer software development, provided working models of technology applications and a foundation for statewide activity.

Many Minnesota school districts are sought out for their computer expertise. The plans of the Minneapolis public schools demonstrate the extent of this expertise. Within the last year, the State's financial picture has changed, significantly. In struggling with an $850 million deficit, the legislature has begun cutting the $2 billion (2-year) education budget. The cuts, an estimated $120 million, are expected to take effect in 1982-83. Educators across the State are concerned that these reductions will affect teaching positions and programs.

MECC: A State Computing Agency

Presently in its ninth year of operation, MECC operates the world's largest general-purpose, educational, time-sharing system. An estimated 96 percent of Minnesota's students have access to this time-share system, which is available to its users from 7 a.m. to 11 p.m. daily. While time-sharing access has remained fairly constant, with a slight increase in off-hour use, the acquisition of microcomputers in the State has accelerated, resulting in a significant increase in computing activities available to students.

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[1] Data Newsletter, Minnesota Educational Computing Consortium, January/February 1981.

History

In 1972, concern about computing and education led to discussions among the Governor, the chancellor of the community college system, the State commissioner of education, key State legislators, and private citizens. As a result, remembers John Haugo, former executive director of MECC, a task force was established by then Governor Wendell Anderson. Haugo was hired to head the planning effort, which resulted in a report that was essentially the plan for MECC. In retrospect, several factors were critical in initiating a major statewide educational computing effort that involved elementary, secondary, and higher public education.

First, the computer industries based in Minnesota (3M, Univac, Honeywell, and Control Data Corp.), created interest in, and awareness of, computing. These corporations also provided many computer resource personnel. Second, instructional computing was beginning to catch on, and educators were concerned that if they failed to take an active role, it would develop without their input and direction; there was concern that noneducational agencies would take charge. Third, there were examples of successful, cooperative, instructional computing ventures principally among the Suburban Minneapolis schools, the Total Instructional Education Service (TIES) consortium, and evidence that technology could deliver instructional services. With this was also a growing interest in cooperation and sharing of resources. Fourth, there was concern about the increased demand for computing services and the proliferation of hardware systems in various educational institutions. Fifth, there was recognition that educational funding constraints would limit operations, while a consortium would not be so limited. However, the most important factor, as far as the legislators were concerned, was equality of educational opportunity. The legislature was sold on the notion that computing opportunities ought to be available in all parts of the State.

The plan, therefore, was to provide access to the central computer through a telecommunications network. The State would subsidize the telecommunications cost to provide equal opportunity to all systems, even those most distant from the central system. Funding for the system and specific services to users would be contracted annually. Each school district or agency determined what they needed. The budget requests were developed and sent to the legislature.

Getting the time-share system to work was no easy task. In fact, there were many problems with hardware, telecommunications lines, and software systems. It took at least a year before the system was operating.

MECC Organization and Functions

MECC was established in July 1973 to provide computer services to students, teachers, and educational administrators. Organized under the Minnesota Joint Powers Law, its member systems include:

- State Department of Education (433 school districts);
- Minnesota State University System (7 campuses);
- University of Minnesota (5 campuses);
- Minnesota Community College System (18 campuses); and
- State Department of Administration (statutory authority for State University and Community College Systems).

MECC is responsible for coordination and planning—maintaining a long-range master plan for educational computing and developing biennial plans, providing technical reviews of proposals for facilities and services, and reporting on what is being done with computers by all of public education. MECC is also responsible for services to members, and it is this role that is being expanded (by the revised Joint Powers Agreement, August 1981), while the organization's policymaking role and its role in approving major computer acquisitions is being reduced. The latter activities will be determined by the State Board of Education with the Commissioner of Education.

Instructional Services Division

Operating the Time-Sharing System. The Instructional Services Division (ISD) runs the world's largest educational time-share system. It works reliably, and is "up" 99 percent of the time. Its Control Data Cyber 73 System, with 448 user ports, is currently accessed by more than 2,000 terminals located across the State in most public schools, all community colleges and public universities, and many of Minnesota's private schools. A multiplexing communications network with 23 hubs provides access to the computer.[2] ISD is also responsible for the communications network—its installation, maintenance, and coordination with local telephone companies.

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[2] *Instructional Microcomputing and Timesharing: A Minnesota Perspective,* MECC Instructional Services Long Range Planning Project, 1981, p. 39.

An extensive library of programs supports a range of activities from drill and practice to mathematics problem generators, office management, and career guidance information. Thirteen different computing languages and programs are available to users. Software is continually maintained and improved.

Technical Assistance and Training. Through ISD, instructional computing coordinators are located throughout the State in each of the regions. These regional coordinators work with teachers who in turn serve as local coordinators for the school district or education agency. According to Will Jokela, MECC Instructional Coordinator for Central Minnesota, these local coordinates are crucial to the program. "They make things happen and are part of the whole planning and implementation process."

For example, when Jokela conducts workshops across his region, he often uses local coordinators as resources. Jokela also holds sessions to demonstrate new programs for local coordinators, and these are often times when they share programs developed locally and duplicate MECC microcomputer programs. He keeps up with computing activities through the electronic mail system (also part of time share) and through visits to local schools and colleges. The regional coordinators help in disseminating information in the newsletters, through conferences, and through the electronic mail system.

At the same time, Jokela and others in his role became the link in continuing advances and changes. Soon after the MECC inexpensive computer contract was awarded, Jokela was "trying out the Atari" and getting ready to demonstrate its use to interested educators. He also delivered and installed the Apples purchased through MECC, and literally carted Apples across central Minnesota. Of his 73 public school districts in Region III, all have Apples and 62 used the timeshare system in 1981-82.

Since the first purchase of Apple microcomputers in 1977, increasing amounts of the coordinators' time have gone into supporting microcomputers. Marcia Horn, an instructional coordinator in the Twin Cities area, points out that as soon as a workshop is announced, it is filled. Horn is impressed with the eagerness to learn and the excitement of those who attend her MECC introductory courses. In the sessions, technology is manipulated, not just talked about. That participants recognize the need for hands-on experiences is indicated, in part, by their willingness to bring all the equipment to class. Microcomputers and diskettes replace books, paper, and pencils, as learning tools. Principals, teachers, and librarians learn about and learn with the technology, in much the same way as do their students.

Developing Instructional Computing Software and Support Materials; Dissemination and Distribution. Software that has been designed and developed includes operating system manuals, computer literacy courses, and a range of supplementary instructional materials and management aids. Development is directly linked to the users (through the creation of software at the local level), to field testing and revision, and to implementation. Networking, originally begun through the time-sharing system, has been extended through the State instructional computing conference, regional meetings, the newsletters, and the other user activities.

What is clear is the value of sharing ideas, of providing a vehicle for development, and of disseminating this new information to users. Individual teachers, school districts, and regional organizations contribute software. MECC staff work with the developers to obtain rights to the material, then they document and standardize it so that other schools can use it. All software and support materials are available to Minnesota users (for copying) free or at nominal cost.

In October 1980, institutional memberships were offered to nonprofit educational institutions outside of Minnesota. Presently, there are 51 members in 23 States, Canada, Australia, England, Kenya, Saudi Arabia, Scotland, and Switzerland. In addition, software reproduction and distribution rights are arranged with commercial vendors under a royalty agreement. The income from these agreements and sales goes directly back into software development.

Management Information Services Division

Management Information Services supports a range of administrative management functions. Every school district in the State is required to use the finance reporting system developed by MECC. This division has also developed a student support system that handles student data, attendance, scheduling, reporting, and history. The personnel/payroll system is used by half of the districts in the State.

Special Projects Division

The Special Projects Division carries out research projects, developments of new applications, and evaluation. With funding from the National Science Foundation (NSF), computer literacy curriculum modules and support materials are being developed. An interactive video disk/microcomputer course in economics is under way with support from private foundations.

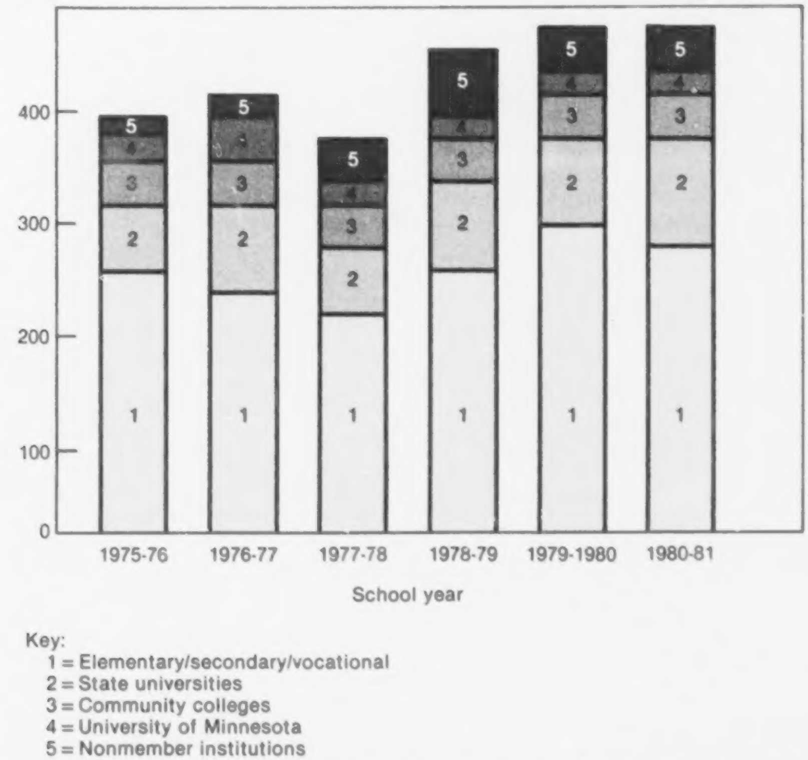
Impacts

Providing Access to Computing: Instructional Time Sharing and Microcomputing. Not only access but *equal access* has been Minnesota's goal for all students. From the very start, it was recognized that there was a need to achieve economy of scale in computer hardware acquisition, to create a cost-effective communications network to minimize the systems design and development costs, to share expertise and applications, to have uniformity and compatibility of data (administration), and to train educators.

The use of the time-sharing system has been fairly consistent in time of the number of ports purchased by users and the increase of log-ins and connect time, which increased by approximately one-third during 1978-81 (see fig. A-2). Of the elementary, secondary, and vocational school districts, 75 percent used the time-sharing system, a slight reduction in use. At the same time, however, microcomputer use rose from 57 percent the year before to 85 percent of all districts.

The major use of the time-share system is for programing—up to 45 percent—with students from all over the State having access to almost a dozen different programing languages. The impact of these opportunities is not readily assessed through numbers, but clearly many of these student users have become outstanding programers. Winners of the MECC annual student software

Figure A-2.—MECC Timesharing System Port Distribution by User System, 1975-81



SOURCE: *Instructional Microcomputing and Timesharing: A Minnesota Perspective*, Report of the Instructional Services Long Range Planning Project, Minnesota Educational Computing Consortium, June 1, 1981.

competition develop creative and impressive products. "Many of the future technology leaders will come from Minnesota," notes Brumbaugh, "having had 8 to 10 years of computing opportunities in the public schools as well as training at the University of Minnesota's world-renowned computer sciences programs." Minnesota benefits directly, since many of these high school and college students are hired as part-time programers at MECC and many enter Minnesota-based industries.

The impact on increased access by MECC's early entry into microcomputing with the award of the State contract to the Apple Computer Co. is clear. The decision to standardize hardware to one system was based on the belief that standardization was necessary in order to be able to support that system with software and training, thereby indirectly affecting access. (By early 1982, total Apple sales reached 2,863.) Most of the purchasers of these microcomputers are elementary, secondary, and vocational schools.

In 1981, MECC developed a second set of specifications for a low-cost microcomputer. The State contract was awarded to Atari, which agreed to pay MECC to convert at least 75 of existing MECC/Apple programs. In the first 3 months of the Atari contract, 230 microcomputers had been purchased.

A major reason that districts are purchasing microcomputers is to provide greater access. The high school in Maple Lake, a small rural district, has three Apples, one TRS-80, and one time-sharing port. Before the microcomputers, the 500 students had limited computing experience through time sharing. Even though four microcomputers aren't enough, they make a big difference to Mary James, a teacher and the district's computer coordinator. James is adamant about reaching every Maple Lake youngster:

> By the time they are 35 they all will have computers—many for their farm businesses—others in technical work (if they leave Maple Lake)—and for recreation . . . if most families have three snowmobiles sitting in their driveways now, they'll soon have computers, too.

It's not just the hardware that makes a difference, it's the support James gets from the range of MECC services. In this rural district, with an operating budget of $2.5 million for 1,320 students, the opportunity to use computers for instruction and to provide computer literacy courses and independent study, is due in large measure to MECC and to local administrative and school board support. James says:

> If MECC drops the time share we'd feel it . . . the larger city districts will continue. If I lose the port, I can stand it. If I lose the support of MECC, the whole program goes.

Developing Software and Making It Available to Users. Software and support materials have been steadily developed and revised to support the time-share system, the Apple microcomputer, and the Atari microcomputer. On the time-share system there is a library of more than 950 programs used at all levels. More than 200 microcomputer programs have been developed, and the number of new programs continues to expand at a rate of 8 to 10 new programs each month.

Although software development has been focused on Minnesota users, in the case of materials for the Apple (and now the Atari), two-thirds of the software distribution (primarily for the microcomputer) is outside the State. Single-item sales, institutional licensing agreements, and distribution arrangements with commercial vendors have increased significantly over the last 2 years. MECC officials point out that all of the income from software sales goes back into development. The current budget for development has tripled, with only 5 percent of the funding for software development coming from Minnesota. According to Brumbaugh:

> The amount of resources invested in instructional computing material development continues to grow, without any reduction in sight . . . It's estimated that 250,000 copies of MECC diskettes have been distributed or sold to computer users throughout the world. Software sales this year are expected to reach one million dollars.

Software development has been effective because it has been tied to what teachers want. Actually begun by teachers sharing ideas through the time-share system, it has continued to build on teacher ideas. Much of the software has primarily been cleaned-up, field-tested, documented, and made available to users by MECC. Another reason for success, many argue, was the decision to develop software for one microcomputer system. This decision provided an opportunity to refine authoring procedures, understand the capabilities of the machine, and develop more programs (e.g., instead of three programs for three machines, nine programs for one machine). After the award of the second computer contract, it was not difficult to convert many Apple programs for the Atari. The need and demand for microcomputer courseware in Minnesota continues, however. In MECC's 1981 Computing Opinion Survey, "Schools want materials in all subject areas—with the highest priorities given to computer science, business education, mathematics, science, and special education," with less need for drill and practice and games and more need for problem solving, tutorial, and simulations.[3]

Local districts will continue to develop their own software and will also continue to purchase commercial software. For the latter, it may be desirable to provide help to schools by developing statewide purchase contracts for software, as has been done for hardware. Finally, as the market for software enlarges, there will be an increase in development in the private sector, argues Haugo, now president of a software development company.

Impacts of Information Technology

Professional Development and Training. Professional development and training is cited frequently as a major area of need that must be addressed if education is to take advantage of computer technology. Over a 6-year period (1974-80), MECC has provided significant development and training activities: 3,572 visitations by MECC staff to districts and campuses; 1,639 informal presentations; 1,756 workshops with a total attendance of 26,340; and 623 meetings for local computer coordinators. As impressive as these figures are, MECC officials point out that the demand for training exceeds capacity. Brumbaugh notes: "For every request for service that we fill, we turn one down." Although many local districts provide additional training activities—the educational service unit or area vocational technical institutes and colleges and universities are offering an increasing number of courses—the needs for training are not fully met.

Furthermore, as State funding resources diminish, continuing to provide the current level of services will become a problem. According to Brumbaugh, there has to be a way to deal with teacher turn-over (trends show that the more highly technologically trained teachers leave), with new teachers as they enter the system, and with maintaining training for those who want to stay abreast of technological advances. When asked who should do inservice training for instructional computing, teachers and administrators ranked MECC staff as the most desirable—followed by local staff, then regional service centers, and finally colleges and universities. Data suggests that local staff will be able to assume most introductory demonstrations, but more advanced topics and courseware authorizing and design will require MECC staff.

Close Ties With Local Districts, Using Local Expertise. The superintendent of the Alexandria Public Schools, Clayton Hovda, attributes his district's early involvement with computers to the opportunity to be part of the statewide time-share system, as well as to the fact that MECC from the very start had key people "who came through the educational process, who knew how schools worked because they were school-based." There was and continues to be a symbiotic relationship between the schools and MECC.

For example, the Alexandria schools shared computing and time-sharing facilities with the Area Vocational Technical Institute (AVTI). That experience, along with other examples (TIES), provided a model for extending the time-share concept across the State. A further example of this symbiotic relationship can be seen in the role of the local computer coordinators. According to Bill French of Alexandria, this role is strongly supported by MECC; the fact that most districts have a computer coordinator can be credited to MECC's efforts.

Providing Leadership. There is no question about MECC's leadership in providing hardware standardization, software development, and training. However, several school districts and regional agencies are leaders as well; and districts such as Hopkins and Robbinsdale have received national recognition for their computing activities. It is apparent that MECC walks a fine line: local autonomy of programs is highly valued, yet service and assistance are welcomed. The revised Joint Powers Agreement puts MECC squarely in a service role. It is also agreed that there is a need for leadership and coordination to maintain and advance computing applications; in this regard MECC, as the State's computer agency, plays a key role.

School districts outside the State, and even other nations concerned with educational computing, have turned to MECC for advice, technical assistance, and resources. For example, the first computer contract specifications developed by MECC became the model for the bids developed by the Region IV Education Services Center in Texas and for those prepared by school districts and several States including Florida, North Carolina, and British Columbia. A recent article which surveyed all statewide computing activities ranked Minnesota as the clear leader.[4] "No other State education agency comes close to achieving the level of commitment and organization achieved by MECC. But many State officials are now realizing that it may be their responsibility to move in that direction."

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[3] 1981 MECC Computer Opinion Survey, User Opinion on Training.

[4] "Survey of State Governments and the New Technologies," *Electronic Learning*, November/December 1981.

The Future

With reductions of the State subsidy for telecommunications, increased local costs pose a real barrier to time sharing, especially to the smaller, rural districts further away from the Twin Cities. Although much of the instructional activities can and will be shifted to the microcomputers, a real loss may well be the availability of advanced programing languages and the communications activities and the electronic mail system which tied so many of the districts to one another. Richard Pollack, Director of Special Projects, describes the time-share system as "the glue that brought it all together."

A spate of news stories have highlighted Minnesota's financial difficulties. "What the rest of the Nation's schools have been facing has finally caught up with us," one of the educators remarked. Many districts have begun to tighten their belts by laying off teachers and increasing pupil-teacher ratios. However, many districts, like Alexandria, plan to go ahead with plans for their computer programs. Bill French, teacher and computing coordinator comments: "I can see us buying 4 to 6 Atari's for each elementary school . . . What's $500 when we pay $2,000 for a typewriter or an Apple?" The additional costs for training and software are, in a sense, covered through the services provided by MECC. Although MECC has already had budget cuts and expects more in the future, increasing revenues from software sales will lessen the impact.

Superintendent Arthur Bruning, of the Hopkins School District, a Twin Cities suburb, also expects to expand his program using the low-cost computers. He sees technology bridging home and school, with the computers going home for extended activities. In this district, with an $18 million annual budget, he argues, "We will need to set aside resources for technology—for there is going to be a change (in the way we educate youngsters) and the pupil/teacher ratio will increase because of economics."

Brumbaugh is optimistic. He sees opportunities for expansion of software and new technological advances that will make a difference in instructional computing. One example of these advances is an interface that allows microcomputers to be networked or clustered together. Once clustered, software maintenance is reduced, recordkeeping and management functions are simplified, and centralized printing is feasible. MECC is designing its own interfaces and networks. By fall of 1982, these networks will be field-tested in selected Minnesota schools. In addition, MECC's long-range planners estimate that the number of instructional computing stations in classrooms in Minnesota's schools, colleges, and universities will reach 10,000 by 1984.

Minnesota computer educators also confidently predict continuing developments in instructional computing, pointing to present programs—the result of more than 8 years of experience. The MECC software and materials, training activities, and the range of successful applications in computing, were possible because funding was sustained over a long enough period of time and over a critical mass of educational institutions and users. MECC's accomplishments, the computing activity in Minnesota schools, and the significant number of students with access to these programs is the result of the State's vision and its long-term commitment.

Resources

Case study interviews:

Minnesota Educational Computing Consortium, St. Paul, Minn.
Dale L. Schneiderhan, Acting Executive Director
Kenneth E. Brumbaugh, Director, Instructional Services, and Deputy Executive Director
Douglas P. LaChance, Acting Dirctor, Management Information Services
Richard Pollak, Director, Special Projects
Marge Kosel, Manager, Instructional Systems Development
Marcia Horn, Instructional Coordinator
Kasey Mork, Instructional Coordinator
Willis Jokela, Instructional Coordinator
Minneapolis Public Schools, Minneapolis, Minn.
Paul Dillenberger, Math Resource Teacher
Hopkins Public Schools, Hopkins, Minn.
Arthur Bruning, Superintendent
Ken Corens, Computing Coordinator
Don Sension, Computer Center
Maple Lake Public Schools, Maple Lake, Minn.
Mary James, Teacher, Maple Lake High School, and Computing Coordinator
Eagle Bend Public Schools, Eagle Bend, Minn.
Wilbur James, Superintendent
Richard Lundgren, Communicasting Project Director
Alexandria Public Schools, Alexandria, Minn.
Bill French, High School Teacher and Computing Coordinator
Clayton Hovda, Superintendent

John Haugo, former Executive Director, MECC 1973-1981, presently President, Edu Systems, Inc., St. Paul, Minn.

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Instructional Computing Houston Independent School District, Houston, Tex.

The Houston Independent School District (HISD) was selected for study because it is a recognized leader in urban education, in developing innovative programs such as magnet schools and in implementing cooperative efforts with industry and the business community. It has successfully halted declining pupil achievement, a major problem for urban school districts. The district also provides examples of how technology can be used to support and deliver basic skill instruction, to communicate with parents, to assist teachers, and to become the basis for technological understanding and computer literacy.

Moreover, it provides an example of districtwide leadership and coordination through a newly created department of technology and the Nation's first associate superintendent for technology. With a growing minority student population, the district has engaged in a planning effort to address equity and access to ensure that all students acquire basic skills and technological competence. As one of the largest school districts in the Nation, Houston also shows how economies of scale, critical mass, and volume purchasing power can be used to implement new programs and produce software/curriculum materials.

The Setting

The Houston metropolitan area population in 1981 was 2.4 million. It is a highly mobile population with a high growth rate for Hispanics and Asians. A total of 193,702 pupils attend 169 elementary and 70 secondary schools. Over the last 10 years the ethnic makeup of the student body population has shifted from an almost all-white population to one that is 23 percent white, 44 percent black, 30 percent Hispanic, and 3 percent Asian. Approximately 62 percent of the high school graduates attend college.

Houston is at the center of a booming industrial area. Its major industries are oil and gas, banking, construction, and chemicals. There are strong ties between HISD and area industries, the chamber of commerce, and the other business organizations. This relationship has been cultivated by Houston's superintendent, Billy Reagan, over a 7-year period. Through cooperative business/school arrangements, the district's pupils and programs have benefited. For example, magnet schools receive hundreds of thousands of dollars for equipment and scholarships from companies such as Exxon, IBM, DuPont, and others. There is evidence that the district's focus on technology utilization, academic achievement, and career training programs has been positively received by the business community.

The annual budget of $507 million supports a wide array of educational programs for this district's diverse population. The district currently receives $13 million in Federal title I moneys. Houston administrators expect to feel only a slight impact from cutbacks in Federal funds, since most of their revenues are locally generated. Unlike many urban districts, Houston's financial base is thriving and its financial future appears secure.

The following issues facing the district affect educational programs and educational quality:

- The shift from an emphasis on desegregation, to an emphasis on quality integrated education (mid-1970's), to the current emphasis on the prevention of resegregation.

- Changes in family needs (dual wage earners) and an increasing number of single-parent families.
- An increase in the Hispanic population and enrollment, with a critical shortage of Spanish bilingual teachers.
- The shortage of math, science, and computer science teachers; a high teacher turnover rate in critical areas; and difficulty in retaining top-quality teachers.
- The increased computer use in all aspects of society and in the district.
- The increase in community support from parents, patrons, religious organizations, and businesses and professional organizations.
- The increase in student achievement since an all-time low in 1975, and the desire to maintain these achievement gains at all levels.

The major challenges, feels Superintendent Regan, are "continuing to offer quality education in an integrated environment to all children, and attracting and holding nonminority children, both from within and outside the District."

Instructional Computing

In the early 1970's, the district's first instructional computing programs were offered through the Region IV Education Service Center's computer. By 1972, 20 terminals were used for problem solving, drill and practice, and BASIC programming instruction. Math and data-processing classes at the secondary level were primary users. Computing activities were limited, points out Patricia Sturdivant, Associate Superintendent, and there were problems with inadequately documented courseware programs and manuals and with high costs of hardware and associated maintenance costs. The links through telephone lines were unreliable, and when the mainframe was down no instruction was available. Despite these frustrations a small cadre of teachers persevered. These educators, more often than not, were self-taught. Few had computer-science college training.

By 1977-78, Houston's instructional computing efforts were well established. While computer applications varied, the major emphasis was on increasing pupil achievement in reading and mathematics. Not only was this a major priority for the district, but Federal title I funds were used to support these high-cost programs. Student gains were "dramatic," according to high school principal Franklin Wesley.

In 1979, the Region IV ESC established a microcomputer task force, to evaluate what was happening in the region's districts and to prepare recommendations for action. Task force members included Superintendent Reagan, superintendents of the Byran and Orange Cove School Districts, the director of data processing from Spring Branch ISD, and Sturdivant, then Region IV ESC Instructional Computing Coordinator. The task force found that use of time sharing had leveled off (after 5 years of steady growth), that interest in microcomputers was high, and that microcomputers were being purchased with "insufficient planning, and little understanding of their potentials or limitations." After purchase, districts were faced with inadequately trained teachers, a shortage of software, and a lack of technical support for hardware operation and maintenance.

The report recommended that hardware be standardized to facilitate training, maintenance and software exchange and development, and that high-volume purchase arrangements be made to reduce costs. Bid specifications were developed, and in June 1980, Bell and Howell's Apple II Microcomputer System was selected.

The Region IV Instructional Computing Services Division served as the fiscal agent for school districts purchasing microcomputers. High-volume purchases resulted in savings close to a million dollars over a 2-year period. In addition, the center provided computer literacy training to area school administrators and teachers, with more than 3,000 teachers receiving training. The center also offers a low-cost maintenance service for computer hardware; publishes a monthly newsletter; coordinates courseware purchase and selection; loans video tapes, films, and other training materials; and offers special workshops to meet the needs of individual school districts in the region. The working relationship between HISD and the service center is evidenced by Reagan's choice of Sturdivant as his new associate superintendent for technology.

Current Programs

By October 1981, the district survey of microcomputers reported 200 microcomputers located in 47 percent of HISD campuses. The most frequently used system is the Apple II, 48K. Local funds were used to purchase 45 percent of the microcomputers in the school buildings, while Federal funds paid for 31 percent. Parent-teacher organizations bought or helped to buy about 4 percent of the systems. Of those reported uses, 44 percent focused on classroom instruction; 29 percent were used for classroom management, and only 4 percent were used in school administration.

A year and a half later (March 1982), the estimated number reached 323. While use of the terminals linked to a minicomputer has decreased, several elementary and secondary campuses continue to operate drill and practice laboratories for compensatory (title I and SCE) and handicapped students.

Managing Competency-Based Education. The Booker T. Washington High School's competency-based education program for students uses the school's PDP-11 to score student tests, monitor student performance on specific learning objectives, and report progress to teachers. The school's principal, Wesley, argues that this approach is working for this school's depressed economic community and its predominantly black population of students who are at the bottom of the academic scale.

Computer Science/Programing Languages. Housed on the same campus (Booker T. Washington) is one of the district magnet programs—the High School for the Engineering Profession. These students take computer science courses in BASIC, Fortran, applications, and problem-solving, using terminals connected to the school's PDP-11. The school's computer science teacher works jointly with an engineer on loan from IBM. Other secondary schools offer computer science courses of instruction in several programing languages on both time-share terminals and microcomputers. In some elementary schools, students learn programing in mathematics.

Project BASIC. All secondary schools have implemented Project BASIC, a commercially developed program for HISD's Apple microcomputers which monitors reading lab students' progress and tracks their mastery of reading skills. Before implementing the program, extensive training took place: first of principals, then reading teachers, and finally technical aids who input data and retrieve information on the microcomputer.

Implemented in the 1981-82 school year, the project required a reorganization of the secondary reading labs, more than $600,000 (primarily SCE funds) to purchase hardware, software, and materials to operate the labs, and reallocation of existing operating funds to hire 67 basic skills computer operators, one media equipment maintenance technician, one supervisor, six area reading specialists, and one systems analyst.

Computer Literacy. A computer literacy curriculum, developed by Region IV ESC, is being piloted in five elementary schools with language programs for gifted and talented students. At Askew Elementary, students learn about computers and their impact on society. Their parents are also involved. Together, they find microprocessors that they use at home, and they collect and read newspaper and magazine articles. In class, students have experiences with the computer in drill and practice, simulation and tutorial activities. Finally, they learn simple programing routines. These students seem to enjoy all the activities, notes one of their teachers—particularly hands-on experiences. "They love it so long as they have a computer on the end of it."

Operation Fail Safe. The district's computing power has also been used since 1977 in a unique parent involvement program, Operation Fail-Safe. Although not a teaching application, the program affects the instructional program. It is designed to reach parents, communicate information about their children's achievement, and help parents help their children (see fig. A-3).

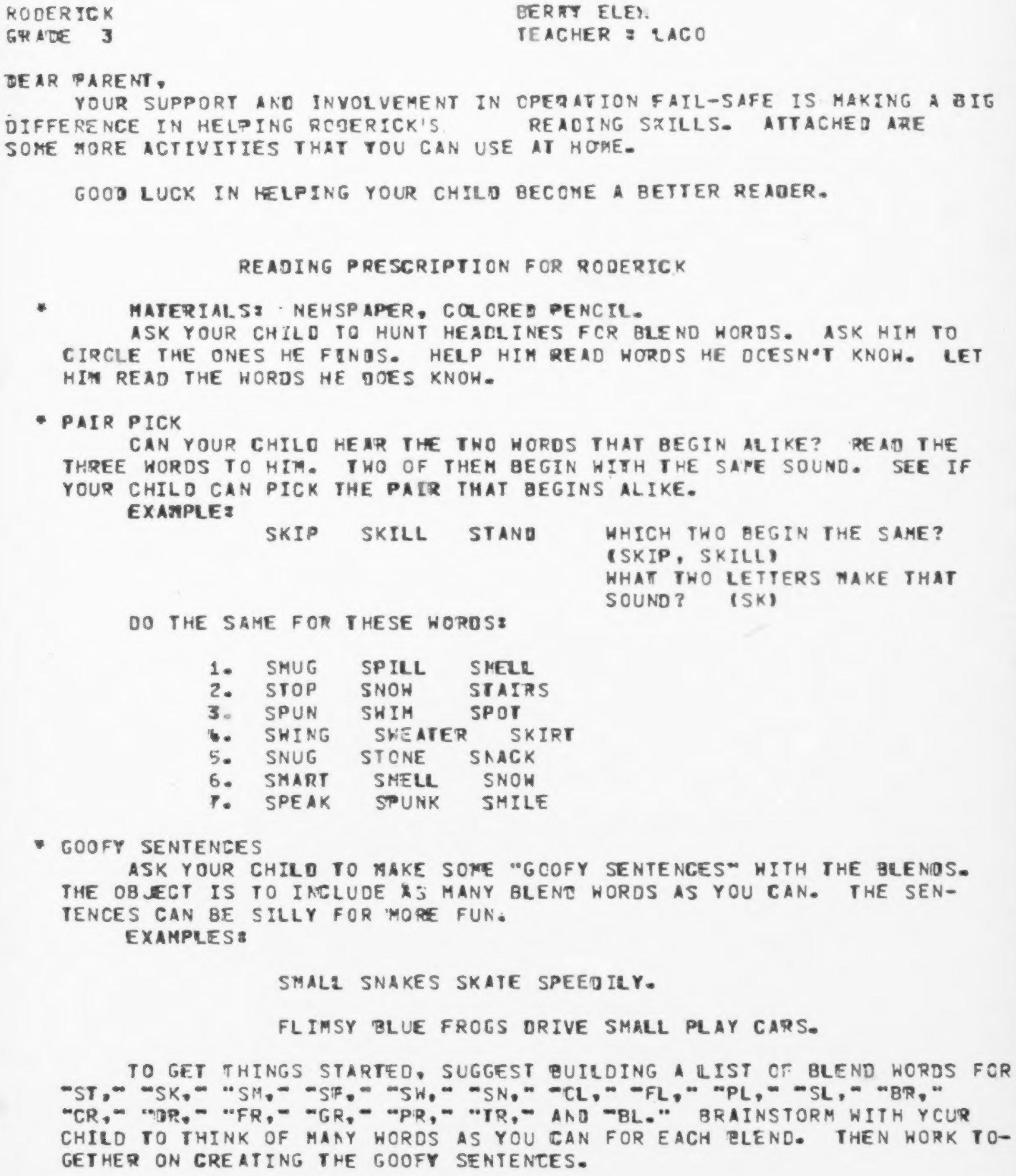
This system-wide program is an example of how computer technology has been used to provide important data on a timely basis and on a massive scale, impacting 200,000 pupils, notes Sara Cordray, program director. Using the Region IV twin CDC Cyber 170 mainframe, HISD profiles each student's performance on the Iowa Test of Basic Skills; generates progress reports listing specific skill strengths in reading and math; develops individualized reading lists (sent home as a letter to each parent) based on each students' interest and independent reading level from a data base of 12,000 library books; and prepares vocational profiles based on a standardized assessment of each student. (Accompanying each profile is a printout of occupational opportunities and education and training requirements.)

Other current uses (documented in the HISD Microcomputer User Survey) of the microcomputers vary from school to school. Microcomputers are used in mathematics, reading, science, language arts, accounting and business education, special education, computer literacy, and programing activities. Some schools have computer clubs and some offer classes after school for students and parents. Some teachers are creating their own software, and others use commercially prepared materials.

Impacts

When Houston educators assess the impacts of technology on education, they point to improved

Figure A-3.—Sample "Fail Safe" Parent Letter



RODERICK   BERRY ELEM.
GRADE 3   TEACHER : LACO

DEAR PARENT,

YOUR SUPPORT AND INVOLVEMENT IN OPERATION FAIL-SAFE IS MAKING A BIG DIFFERENCE IN HELPING RODERICK'S READING SKILLS. ATTACHED ARE SOME MORE ACTIVITIES THAT YOU CAN USE AT HOME.

GOOD LUCK IN HELPING YOUR CHILD BECOME A BETTER READER.

READING PRESCRIPTION FOR RODERICK

* MATERIALS: NEWSPAPER, COLORED PENCIL.

ASK YOUR CHILD TO HUNT HEADLINES FOR BLEND WORDS. ASK HIM TO CIRCLE THE ONES HE FINDS. HELP HIM READ WORDS HE DOESN'T KNOW. LET HIM READ THE WORDS HE DOES KNOW.

* PAIR PICK

CAN YOUR CHILD HEAR THE TWO WORDS THAT BEGIN ALIKE? READ THE THREE WORDS TO HIM. TWO OF THEM BEGIN WITH THE SAME SOUND. SEE IF YOUR CHILD CAN PICK THE PAIR THAT BEGINS ALIKE.

EXAMPLE:

SKIP SKILL STAND — WHICH TWO BEGIN THE SAME? (SKIP, SKILL) WHAT TWO LETTERS MAKE THAT SOUND? (SK)

DO THE SAME FOR THESE WORDS:

1. SMUG SPILL SMELL
2. STOP SNOW STAIRS
3. SPUN SWIM SPOT
4. SWING SWEATER SKIRT
5. SNUG STONE SNACK
6. SMART SMELL SNOW
7. SPEAK SPUNK SMILE

* GOOFY SENTENCES

ASK YOUR CHILD TO MAKE SOME "GOOFY SENTENCES" WITH THE BLENDS. THE OBJECT IS TO INCLUDE AS MANY BLEND WORDS AS YOU CAN. THE SENTENCES CAN BE SILLY FOR MORE FUN.

EXAMPLES:

SMALL SNAKES SKATE SPEEDILY.

FLIMSY BLUE FROGS DRIVE SMALL PLAY CARS.

TO GET THINGS STARTED, SUGGEST BUILDING A LIST OF BLEND WORDS FOR "ST," "SK," "SM," "SP," "SW," "SN," "CL," "FL," "PL," "SL," "BR," "CR," "DR," "FR," "GR," "PR," "TR," AND "BL." BRAINSTORM WITH YOUR CHILD TO THINK OF MANY WORDS AS YOU CAN FOR EACH BLEND. THEN WORK TOGETHER ON CREATING THE GOOFY SENTENCES.

SOURCE: Houston Independent School District.

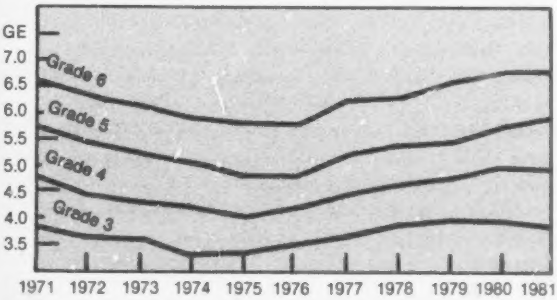
BEST AVAILABLE COPY

student achievement. The profile of HISD elementary students' mean composite scores from 1971 to 1981 documents the increased basic school performance of a student population who typically are low achievers (see fig. A-4). In 1980-81, the district completed its sequential testing program through grade 12. Although the results at the elementary level are more impressive, scores in grades 5, 7, 8, 9, 10, and 11 also show a significant improvement in achievement. Although not the sole factor, technology plays a critical role.

When the title I computer-assisted instruction (CAI) program was evaluated, students in grades 2-6 averaged gains of 1.1 months in reading and 1.2 months in mathematics in 1978-79. Students in grades 3-7 made similar gains of 1.1 months in reading, 1.4 months in mathematics, and 1.5 months in language in 1980-81. Of teachers whose students participated in the CAI labs, 93 percent felt that student performance improved as a result of CAI and 63 percent reported that students' achievement was greater than would be expected in a traditional instructional program. While students looked forward to CAI classes, teachers complained about the disruption to their classes when students were pulled out. Scheduling was fixed and inflexible. Moreover, when computers were down or telephone lines malfunctioned students missed instruction.

Operation Fail Safe was evaluated in 1977-78 to determine the relationship between parent involvement and student achievement. The level of parent involvement, determined by the school principal, was compared with students' achievement test scores. At every level—elementary, junior high, and senior high—a significant positive relationship was documented. A second study of a pilot parent-assist program involved 200 parents of third grade students in four schools. After students' reading skill areas were identified, materials were prepackaged and distributed weekly for parent-child use at home.

Figure A-4.—Iowa Tests of Basic Skills, Mean Composite Scores, HISD, 1971-81



SOURCE: Houston Independent School District.

A comparison of these students and a control group (students not participating in the program) revealed higher significant gains for pilot students. Beyond these statistical gains, Operation Fail Safe has the strong support of the business community. Local businesses and corporations have paid for a $1 million advertising campaign that highlights parent involvement activities with the message, "Don't Fail Me—Help Me." Seventy-four percent of elementary school parents and 39 percent of secondary school parents attend the program's parent-teacher conferences.

HISD and the Region IV ESC have provided leadership for the 101 local area school districts and for the State education agency. The Apple microcomputer bid process and contract had national recognition and was used as a basis for other district and regional education agency efforts. Region IV was one of the first to join the Minnesota Educational Computing Consortium (MECC) as an institutional member, providing area schools access to MECC-produced software.

HISD organized a technology conference for the National Institute of Education's Urban Superintendents Study Group in December 1981. The conference brought together educational leaders, hardware manufactures, and educational publishers to discuss common needs and to work towards collaborative efforts.

Finally, the district is bombarded with requests for information and for help—"everything you know about computers." There is a steady stream of visitors who come to observe programs and see teachers and students in action.

As HISD moves its technology programs forward, Sturdivant sees the need to help schools to effectively use the technology that they have. She believes that, before schools acquire hardware or add to their inventory, they must plan for their use. That involves an understanding of the technology's potential and its limitations, the learning objectives to be met, and the trained teachers needed to implement the program. Sturdivant is also in favor by focusing on a few applications at a time, so as to give the district leverage for purchasing hardware and software. The major publishers will provide what the district needs "if they know we will buy." The full impact of technology on HISD will come when "technology is fused to education . . . to what teachers are doing . . . and (is) not another add-on to the curriculum. If teachers can't be convinced that technology will make their job easier, they're not going to buy it."

In addition, here will be a concerted effort in HISD to continue to identify those programs that are working and to replicate them. The key, states Associate Superintendent Michael Say, "is to channel the use of technology and coordinate it . . . Houston is on the verge of moving ahead in a significant way." The district will fund the emerging programs out of State and local funds because "we want to determine our own emphasis and maintain our own programs." Federal funds, he argues, should be used for innovation and state-of-the-art development.

Future

For HISD, the future is now. Although technology is already a part of the Houston educational scene, with diverse activities well under way, there is a pervasive feeling among educational leaders that hard decisions must be made, innovative actions initiated, and major resources reallocated as quickly as possible. At the same time, cautions Say, "We can't just throw technology out there and expect it to be used." Houston's efforts will focus heavily on teacher and administrator computer-literacy training, and on acquisition of hardware and software that is coordinated with planned program development. Superintendent Reagan believes technology holds "untold promises . . . not to replace teachers but to become the full partner of the teacher." The district's future plans are diverse; several are close to implementation or are already under way. Other plans are 2 to 5 years away from completion.

New Roles for Teachers. The position of teacher technologist with pay incentives (increased salary supplements) has been approved. Teacher technologists will teach teachers, parents, and youngsters and serve as catalysts, planners, and implementers of computer literacy and other programs on individual school campuses. These teachers will draw on the small cadre of staff members already implementing programs, as well as on others who are ready to move into this role. It is hoped that these new opportunities and increased pay will hold the district's trained teachers and attract new recruits, many of whom are choosing industry for their careers.

Extensive Staff Development. Through existing programs offered at the microcomputer center and through the establishment of additional centers and demonstration projects in schools involving teacher technologists, training activities will be significantly expanded. First priority for awareness and training activities will be school principals. School officials note that the principal is the key figure in program implementation.

Expanding the Use of Microcomputers as Instructional Delivery Systems in the School and Home. School officials expect the number of microcomputers in HISD to increase from the present 250 to 300 to approximately 1,000 in a year and to 5,000 to 7,000 in 5 years. A major use of these machines will be to increase student time-on-task in basic skill areas, especially in title I schools. Moreover, microcomputers will be made available to parents who have participated in training sessions and who are willing to help their children increase academic skills at home. Pilot programs will begin in September with schools that have implemented parent-school training and the Operation Fail-Safe partnership activities.

Although there is a lack of available, appropriate software, district leaders believe that there is enough to begin the programs and that more will follow as the microcomputers are purchased, and the district envisions software lending libraries available to parents who will purchase hardware on their own. Eventually, Houston's cable system will become part of home-school activities, with individual student prescriptions, homework assignments, and a range of learning packages geared to terminals in the home.

Computer Literacy for Diverse Student Populations. Over the next 4 years, the district plans to expand and develop magnet elementary and secondary schools located near major government, business, industry, higher education, and cultural centers of the city. This in-town consortium of magnet schools will be linked together by common program components and a common HISD transportation system. The plan is to integrate diverse cultural, racial, and socioeconomic student populations by offering a strong academic program that integrates the use of the computer as an instructional tool in skill development and enrichment activities.

Educational programs will take advantage of nearby resources, expanding HISD's Business School Partnership Program, which brings volunteers into the schools to tutor, teach minicourses, and organize field trips. These magnet programs will also use the resources of libraries, museums, universities, colleges, and community centers. With the increased focus on technology, the practical technical expertise of resource people from industry and the business community will play an even more important role.

Developing Technology-Based Courses. One way to deal with the district's critical shortage of math, science, and bilingual teachers is to develop courses that do not require a full-time teacher. Although not on the district's immediate horizon, there is a growing idea that such courses, minicourses, and the like can be developed because of advances in computer and video disk technologies. There is also a plan to make better use of the district's in-house television and cable capabilities by designing remote-learning stations with instruction coming from a teacher in one location.

While some educators see these plans as visionary, others point to HISD's innovations in other areas and argue that, under Superintendent Reagan's leadership, these ideas will become reality. The superintendent is a powerful persuader: "Unless technology—i.e., the microcomputer, the video disk, and television—is fully developed and exploited to the maximum degree, we will fall further and further behind in Houston in providing the manpower for industry, for our defense, and for our future."

Resources

Case study interviews:

Houston Independent School District, Houston, Tex.

Billy Reagan, Superintendent
Michael Say, Associate Superintendent for Instruction
Patricia Sturdivant, Associate Superintendent for Technology
Ronald Veselka, Assistant Superintendent for Research and Evaluation
Sara Cordray, Program Administrator, Parent Support Programs
Frank Wesley, Principal, Booker T. Washington High School
Richard Frazier, Teacher, Booker T. Washington High School
John Roustenstraugh, Test Engineer on Loan from IBM and Teacher
Helen Heard, Principal, Askew Elementary School
Two classrooms of gifted and talented students using microcomputers
Joy Louisa, Principal, River Oaks Elementary School
Susan Otto, Teacher of K-5 computer literacy classes
Madeline Reed, Director of Mathematics
Carol Kukendahl, Director of Reading and Language Arts
Patsy Rogers, Computer Resources Director, Microcomputer Center for Teachers

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Information Technology and Education in the State of Alaska

The State of Alaska is providing extensive and varied applications of computer and communications technology to education. Special geographic, demographic, sociological, and financial factors have made the State a forerunner in educational information technology. Alaska has a population unusually receptive to change and technology; a compelling need to apply communications and information technology to education; and the financial capability to invest in capital-intensive innovations.

Although many of the technical, political, legal, organizational, and educational issues and problems being addressed in Alaska are common to other parts of the United States, the special circumstances of Alaska require that any attempt to generalize from Alaskan experience be done carefully. Given this provision, it seems reasonable to look to Alaskan experience for useful lessons in the application of technology to education.

The Setting

Alaska is the largest State in the United States, covering a land area equal to about 20 percent of the remaining 49 States. Physically separated from the contiguous 48 States, it is characterized by rugged terrain, extremes of climate, low population density, limited land transportation, and many small isolated communities accessible only by sea or air. The total population of 400,000 includes 50,000 native Americans who belong to seven major and distinct culture and language groups. Over 50 different native languages and dialects are spoken in the homes. Alaska's population overall is relatively young. The frontier character of the region attracts pioneering young adults, while the rigors of life discourage retirees from remaining for their later years.

Alaska has about 90,000 school-age children distributed over an area twice the size of Texas. Alaska's 450 public schools vary in size from 2,500 students in an Anchorage high school to 8 or 10 students in one-room schools in remote areas. Although some of the 52 school districts in Alaska are geographically larger than those in most other States, they may have only about 1,000 students. The State is required by court decision to provide education to students aged 7 through 16 in their home communities, rather than by sending them to boarding schools in other communities.

In rural communities, most students are native Americans who have only brief history of schooling. The educational level of many parents is low, and the benefits of standard American schooling are not necessarily valued. Many of the students have a history of poor academic performance and a negative view of schools.[1]

The recent discovery and exploitation of oil in Alaska has provided the financial capability to invest large sums of capital in education. In addition to the average per pupil expenditure of nearly $7,000, there are special projects—such as $200 million for construction of schools and about $125,000 for the installation of a satellite receiver in a rural village. Rural schools are financed totally by State funds.

It is far beyond the scope of this case study to trace the general history of communications in Alaska. But it is important to recognize that the developments in educational technology in Alaska have occurred in the context of a generally atypical communications situation.

Communications technology that most Americans take for granted—telephones, radio, and television—have had a very complex and problematic history in Alaska. Alaska's long-distance telephone facilities were operated until 1971 by an arm of the U.S. Air Force. The system, served by high-frequency land radio stations, was unreliable because of ionospheric disturbances common to the region. In 1971, 142 villages had no telephone service at all. RCA Alaska Communications bought the system and was certified by the Alaska Public Utilities Commission to provide telephone service.

RCA encountered a variety of difficulties including hindrances by weather, unreliable electric power, employee problems in coping with village conditions, and villagers' lack of sophistication in dealing with the new system.[2] Because of the difficulties of providing communications on a private-industry basis, the Alaska State government has taken a more active role in providing communications.

By the early 1970's, it became apparent that satellite technology offered a more promising means of providing telecommunications services to villages than had any previous technology. Several projects involving satellites were initiated by the State government, including an experiment funded jointly by the U.S. Department of Health, Education, and Welfare (HEW) and the National Aeronautics and Space Administration. (Later transferred to the National Institutes for Education (NIE)).[3] HEW and NIE support for this "ATS-6 experiment" was about $2.5 million.

The ATS-6 experiment involved educational and biomedical applications of satellite-transmitted color television and interactive audio to 19 sites in Alaska. Actual operations lasted only 9 months, during 1974-75, but planning had begun in 1972. The experiment was extensively evaluated and reported on.[4] [5] [6]

While some of these evaluations concluded that the experiment was not cost-effective, the project did build a base of technical expertise in the State with regard to satellite communications technology.[7] For example, a great deal was learned about the use of low-power ground stations.[8] Effectively structured audio conferences for adult interaction were found to be effective for educational purposes.[9] Institutional issues regarding media began to be addressed, such as ways of providing for local (as opposed to State or national) control over media and methods of providing appropriate programing for rural Alaska.

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[1] William J. Bramble and Ernest E. Polley, "Microcomputer Instruction in Remote Vllages in Alaska," Alaska Department of Education, 1981.

[2] A. Hills and M. G. Morgan, "Telecommunications in Alaskan Villages," *Science*, vol. 211, January 1981, pp. 241-248.

[3] L. Grayson, "Educational Satellites: The ATS-6 Experiments," *J. Ed. Tech. Sys.*, vol. 3(2), fall 1974.

[4] B. Cowlan and D. Foote, "A Case Study of the ATS-6 Health, Education and Telecommunications Projects," ARC No. 308.3-C875, EHR-19, Office of Education and Human Resources, Bureau of Technical Assistance, Agency for International Development, Washington, D.C., August 1975.

[5] Office of Telecommunications, "Alaska ATS-6 Health/Education Telecommunications Experiment: Alaska Education Experiment Final Report, vols. I, II, III and Executive Summary" (Juneau: Office of Telecommunications, Office of the Governor of the State of Alaska, September 1975).

[6] Practical Concepts, Inc., *Implications of the Alaska Education Satellite Communications Demonstration for Telecommunications Policymakers* (Washington, D.C.: Practical Concepts, Inc., January 1976).

[7] T. S. Pittman and J. Orvik, ATS-6 and State Telecommunications Policy for Rural Alaska: An Analysis of Recommendations, Center for Northern Educational Research, University of Alaska, Fairbanks, Alaska, December 1976.

In 1975, the Alaska State Legislature provided an appropriation of about $10 million to initiate construction of more than 100 small Earth stations throughout Alaska that would extend satellite-based long-distance telephone service to many communities. The following year, the legislature expanded this satellite network to include television broadcasts for some communities. Since 1977, daytime instructional television (ITV) programs have been broadcast by satellite, and sites receiving these broadcasts have increased in number.

In 1978, the Alaska State Department of Education, with joint funding from NIE and the State, initiated the Educational Telecommunications for Alaska Project. This project, funded at $6 million, has developed several of the major educational technology systems and applications described in this report, including an electronic mail network, an information retrieval system, and multimedia individualized courses.

To help determine the instructional potential of satellite television, the legislature in 1979 requested that a study be made of the feasibility of using television for instruction on a statewide basis. "A Report on the Feasibility of Telecommunications for Instruction in the State of Alaska" was submitted to the legislative council in February 1980. In response to the recommendations of this report, the legislature approved an appropriation of $8.6 million to implement the instructional television and audio conferencing systems now known as the LEARN/ALASKA Network. LEARN/ALASKA is managed by the University of Alaska Instructional Telecommunications Consortium (UAITC), a joint organization of the University and the State Department of Education.

Use of Information Technology

Six major kinds of computer and communications applications are in varying stages of implementation and use in Alaska. These include the following:

- instructional television;
- audio conferencing;
- electronic mail;
- information retrieval;
- individualized study by technology; and
- computer literacy.

Instructional Television. By December 1981, 85 Alaskan communities were receiving instructional television via satellite dish antennas. Additional communities continue to be added to the LEARN/ALASKA television network. The statewide instructional television channel broadcasts nearly 18 hours of programing every day for audience levels ranging from preschool through adult. The programs may be used directly in class or taped for later use.

Most of the programs are purchased from educational program producers in the contiguous 48 States. However, the State of Alaska is now providing funds for Alaskans to produce programing tailored to the special needs of its regional and cultural groups. The Northwest Arctic School District has received a grant from the State to develop programing appropriate for the Inupiaq Eskimos who live in 11 villages scattered throughout the 35,000-square-mile district (about the size of Indiana). Students in Kotzebue are producing ITV programing which can be broadcast live from Kotzebue's transmitter.

Despite the large commitment to State instructional television, many problems remain. First, scheduling of broadcasts to meet user needs is a problem in a State that spans five time zones. Local taping of broadcasts for later use can resolve this problem, but there are copyright issues involved and not all programs can legally be copied. Second, the high cost of developing the needed programs can not be amortized over a large audience due to the sparse populations. Moreover, programing aimed at adults in the home is often ineffective when the home environment is crowded and not a suitable learning environment. Finally, political problems arise when the State-run network is perceived by local cable TV operators to be in competition with private industry.

The cultural impact of television has been an issue of considerable interest since the State first took initiatives in this area. Mechanisms for providing native consumer control over programing, scheduling, and operations have been of major concern since the earliest experiments. For example, James Orvik of the Center for Northern Educational Research observed, "Depending on how the development of a system is managed, early reliance on satellites as the principal means of delivery could be an open invitation to begin centralizing and homogenizing the entire process of media delivery and media use. To the extent such a trend would erode the emergence of local and regional systems, there is cause for concern."[10]

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[8] Personal communication with William Bramble, Alaska State Department of Education, December 1981.

[9] T. S. Pittman, op. cit., p. 15.

One of the strategies that has been adopted to ensure local and regional control for the LEARN/ALASKA network is the provision for regional programing facilities and the establishment of local capability to develop programs.

Audio Conferencing. In addition to instructional television, the LEARN/ALASKA network provides the hardware and the communications capability for audio conferences, which cost about $64 per line per hour to operate. In December 1981, the network had 59 audio conferencing sites; 104 are planned by September 1982. At each community audio conference center a coordinator helps users with the technical and administrative aspects of setting up and conducting a conference. A guide assists users in conducting effective teleconferences.

The University of Alaska has been an early user of this system for education. Students at many of the remote university campuses can join together in class discussions through the audio conferencing system. Some faculty members are beginning to develop expertise in the use of this technology, which, although powerful, requires a considerable amount of administrative time to implement. According to one professor, a faculty member must spend about four times more time administering a course that operates via audio or computer conference than he spends for a similar conventional course. These pioneering faculty are developing expertise in the appropriate structuring, management, and coordination of audio conferences.

Another major application of audio conferencing is for teacher inservice training. This method is highly cost effective in this State, where travel costs are very high.

Electronic Mail. Certain characteristics of an electronic mail system (EMS) make it an ideal technology for overcoming cultural, geographic, and scheduling barriers to education. Through EMS, students with different cultural backgrounds, located in distant places in different time zones, engage in seminar-type discussions with one other and with their professors. Even when all the students in a particular class are physically located at the main campus, they have more interaction with each other and with their professor through the system than they would be able to have in a typical classroom. This is particularly true for native Americans whose minority culture background often results in little class participation. The asking and answering of direct questions in a face-to-face setting is often in opposition to culturally accepted modes of interacting.[11] In Alaska two EMSs serve educational users: the University of Alaska computer network and an EMS operated by the State Department of Education.

The University network is by far the largest, serving 7,000 users at campuses and agencies throughout the State. In the month of November 1981, 104,000 messages were transmitted on this system. Used in innovative ways for learning and teaching, the University's system made it possible throughout the winter for high school students in Nome, Anchorage, Juneau, Kenai, Fairbanks, and Petersburg to participate in an honors program managed by a professor in the mathematics department of the University of Fairbanks. The students received assignments, collaborated with each other, and transmitted their work to the professor through the system.[12] Problems encountered in using the University network for classroom interaction have included: lack of visual material; lack of cross referencing of messages; too many simultaneous threads of conversation; too high a reading level in messages; inability to control negative messages; and student inability to digest unrelated topics.

EMS operated by the State Department of Education was developed by the Educational Telecommunications for Alaska (ETA) project. This network links administrators of the 52 school districts with each other and with the State Department of Education at Juneau. The system is directly accessible only to district administrators, not to school personnel, since the district offices are distant from rural schools. In November 1981, the system transmitted about 3,500 messages. The primary benefit of this system is for State and district administration.

There is no physical interface between the university network and the State EMS. The most commonly cited reason for this is security.

Information Retrieval. The Alaska Knowledge Base, developed as a part of the ETA project, is a computerized guide to help Alaskan educators find current information about curriculum materials, successful classroom programs, and resource people willing to serve in the schools. Users access the knowledge base through the computer terminals located in the administrative offices of the 52 school districts and the department of education. During a 3-month period in 1981, about half the school districts used the system, retrieving about 3,500 items of information from this knowledge base.

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[10] J. Orvik, "ESCD/Alaska: An Educational Demonstration," *J. Communication*, vol. 27:4, autumn 1977.

[11] Personal communication with Ronald Scollen at the Center for Cross Cultural Studies, University of Alaska, December 1981.

[12] Personal communication with Dr. van Veldhausen, Department of Mathematics, University of Alaska, December 1981.

Individualized Study by Technology (IST). A major product of the ETA project is a series of IST courses for high school students in remote schools. These courses are designed to provide instruction that would allow the small, isolated schools to offer a variety of high-quality courses at the secondary level without increasing the staff size and without transporting students to schools in large population centers. When a school adopts IST courses, it acquires an Apple computer. The computer is also used for a variety of other applications such as high school accounting courses, computer science and data processing training, and drills in basic skills.

Six IST courses have been developed: Alaska history, English, developmental reading, general mathematics, general science, and U.S. history. The course packages include student reading materials, lab guides, audio cassettes, teacher guides, text and reference materials, and computer-based exercises and tests. The computer materials operate on stand-alone microcomputers (Apple II). An important component of the course design, computer-based activities provide a high degree of interaction with the student. In pilot tests of the courses the computer exercises were the mode of instruction most preferred by 74 percent of the students. Audio tapes were liked the least.

As typical of technology-based instructional systems, the pilot test evaluations indicate that revisions are needed.[13] "The lack of an overall model for what and how to teach in IST courses has contributed to some of the problems with course design, such as the lack of higher cognitive level tasks, high levels of reading difficulty, and problems with use of audio tapes."[14] Nevertheless, the adoption rate in 1981 far exceeded expectations. As of December 1981, 95 schools had adopted one or more of the courses. Apparent benefits of the IST courses include the following:

- the courses work well for students whose attendance at school is irregular or seasonal, which is the case in many rural Alaskan schools;
- the courses provide more educational options within a small school;
- the computer component is motivating, and the equipment has other applications in the school;
- the courses are complete and self-contained, and are not dependent on local material resources or teacher knowledge of content;
- the courses provide continuity of curriculum in schools where teacher turnover is high.

Availability of the initial IST courses has provided Alaskan educators with an example of what is possible through technology. Demand for additional courses is building, particularly for high school mathematics and science courses. However, it is not clear at this point how development of such courses will be funded, or even how revision and maintenance of the initial courses will be supported.

The cost per student of IST courses will depend on the overall number of students using the courses, the number of students per course per school, and the lifespan of the materials and programs. It appears that the cost per student per course of about $900 will be less than the average Alaskan rural conventional course cost per student (about $7,000). One major cost component for IST is teacher training. In fiscal year 1981, the cost per teacher for training was about $1,500. Travel and per diem expenses accounted for a large proportion of these teacher training costs.

Computer Literacy. In Alaska, as in other States, the availability of low-cost microcomputers has generated considerable interest by educators in computer-related skills that should become part of the curriculum. Several hundred microcomputers are now available for student use in schools, and the number is growing rapidly. The Alaska Association of Computer Using Educators has been formed with the help of the State Department of Education. The department also publishes a newsletter for the association.

By providing teacher inservice workshops in computer literacy and by providing information to educators on available software, the State Department of Education assumes a leadership role in promoting computer literacy. In an arrangement with the Minnesota Educational Computing Consortium (MECC) the department provides copies of MECC educational software free of charge to the schools. It is now establishing a process for evaluating commercially available courseware and will seek to make arrangements with publishers to license distribution of courseware in the State.

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[13] M. Howe, et al., "Individualized Study by Telecommunications Pilot Test Final Evaluation Report," Alaska Department of Education, June 1980.

[14] Educational Skills Development, Inc., "Final Report Evaluation of IST Courses FY 81 Pilot Study," Alaska Department of Education, November 1981.

Computers and Culture. In 1971, the Computer Center Director of the University of Alaska began a series of educational experiments in Alaskan high schools. He hypothesized that the use of computer technology could assist Alaskan natives in overcoming cultural barriers to learning in the classroom. He found that Eskimo children in Nome broke through cultural isolation through the use of Fortran programing; that a teacher could interact with Indian children through computer terminals when they would not interact with him face-to-face; and that Eskimo children gained an understanding of arithmetic through the use of handheld calculators.[15]

Impact on the Use of Information Technology

The LEARN/ALASKA network and the ETA projects have been implemented in the past 2 years and are just now beginning to be used operationally. The impact of these systems on education will not be observable for some time. There appear to be no plans by the agencies involved to monitor or evaluate the impact of these systems.

Knowledgeable persons in Alaska make the following kinds of predictions of the impacts of computer and communications technologies on education:

- curricula of small schools will become more standardized through use of the IST courses;
- nonschool-based education, such as correspondence courses, will become more important;
- individual schools, as opposed to school districts, will assume greater decisionmaking control;
- previously isolated cultures will become more socially sophisticated;
- native languages will disappear; and
- cultural barriers to educational progress will be overcome.

The increasing use of audio conferencing is rendering obsolete some institutional mechanisms and jurisdictional boundaries. Communications networks cut across school district and State lines, raising issues about institutional jurisdictions over accreditation of courses, tuition payments, school schedules, and the like.

Through their varied experiences in the implementation of computer and communications technology in education, Alaskans have addressed issues of design, implementation, and public policy that very likely all Americans will eventually have to address. By no means have all these issues been resolved in Alaska, but there is a more mature understanding of them now than 10 years ago.

- What are the risks involved in technological innovation, and how might they be minimized? According to a model being developed at the Center for Cross-Cultural Studies at the University of Alaska, the risks of wasted capital investment and undesirable cultural side effects can only be minimized if systems evolve with a high degree of user control over growth rate and direction.
- Should the cultural and other impacts of innovation be monitored and, if so, how? There is no formal mechanism for monitoring impacts and outcomes in Alaska. Some believe there is no point in it; others are concerned over our lack of understanding of impacts.
- What is the appropriate role of State government in delivering instruction—e.g., via television or computer-assisted instruction?
- By what mechanisms can educational needs be taken into account in the processes of establishing policies and regulations regarding telecommunications?
- How can educators and users drive the design of innovations?
- How can development of high-quality, user-relevant programing be financed?

The Future

Increasing use of computer-assisted instruction is highly likely in Alaska. The Report of the Governor's Task Force on Effective Schooling recommends "computer-assisted instruction as a viable means of enhancing schooling with respect to the development of skills and acquisition of content."[16]

Application of video disk technology, combined with microcomputers, is planned. The Office of Planning and Research in the State Department of Education has established a design team to analyze authoring systems, assess feasibility of group interactive video disk systems, and prepare recommendations for applications to instruction.

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[15] E. J. Gauss, "Computer Enhancement of Cultural Transition," proceedings of the 1979 National Educational Computing Consortium, Iowa City, June 1979.

[16] Governor's Task Force on Effective Schooling, "Effective Schooling Practices," State of Alaska, December 1981.

Audio conferencing will be combined with instructional television to provide interactive courses. Students watching an instructional television program will be electronically linked together and to the instructor, thus providing a technologically advanced kind of correspondence course.

University students in Alaska will have increasing access to courses at out-of-state institutions via computer and audio conferencing systems.

EDUCOM

EDUCOM was founded in 1964 as a nonprofit organization for colleges, universities, and other nonprofit institutions of higher education. Its current membership includes over 360 university and college campuses in the United States and abroad. The goal is to help its members make better use of computing and information technology. Areas of application are academic instruction and research, college and university administration, and library and information dissemination. EDUCOM provides the following types of services and activities:

- sharing and exchange of specialized computer and information resources;
- consulting on the management and use of computer technology;
- maintenance and dissemination of a financial modeling system;
- conferences, seminars, workshops, and publications; and
- research and specialized software.

Services and Membership Activities

1. *EDUCOM Bulletin.* The *EDUCOM Bulletin* is published quarterly, with a circulation of about 10,000. The bulletin reports on presentations, research projects, applications of information technology to higher education, and systems of interest to the education community.
2. *Annual Conference.* Annual conferences address resource sharing, computer networking, the development of information systems, and other topics of current interest to member institutions.
3. *Seminars.* Seminars in 1981 included, "Managing Microcomputers on Campus," and "EFPM: The EDUCOM Financial Planning Model."
4. *Research Reports and Monographs.* For example, the report of a 2-year, NSF-funded study of factors affecting the sharing of computer-based resources.
5. *Informal Communications.* These include letters to presidents, memoranda, and other mailings relating to the sharing of resources and the use of computing and other technologies in higher education.
6. *Discounts.* EDUCOM provides for discounts on the purchase or lease of computing equipment and related materials and services from selected vendors.
7. *Task Forces.* Task forces are designated to study special issues of interest to members.

Special Activities

EDUCOM provides specialized services through the activities of EDUNET, the EDUCOM Consulting Group, the EDUCOM Financial Planning Model (EFPM), and research and development.

EDUNET. This is an international computing network for higher education and research. EDUNET itself neither owns nor operates any computing facilities. Rather, it acts as a broker, linking using institutions who have unusual computing requirements with 1 of 16 institutional suppliers. Connecting links are established through commercial communications networks, provided by networks such as Telenet and TYMNET. Typical communications charges are $4 to $6 per hour. All arrangements, including billing, are handled centrally by EDUNET.

Planning for EDUNET was initiated in 1966 under partial sponsorship of NSF. Several studies and experiments followed, and a full network was established in 1979. On July 1, 1979, EDUNET became a permanent and self-sustaining activity of EDUCOM.

Membership in EDUNET in June 1981 included 168 institutions. Local access is provided in 250 U.S. cities, 50 Canadian cities, and 30 foreign countries. Resources available from EDUNET supplier institutions include:

- electronic mail and conferencing systems,
- tutorial programs,
- CAI authoring languages,
- statistical packages,
- subroutine libraries,
- planning and analysis models,
- simulation languages and games,
- data bases,
- data-base management systems,

- information storage and retrieval systems,
- programs for textual analysis,
- graphics software, and
- text editors.

EDUNET services also include a hotline, the quarterly *EDUNET News*, the informal EDUNOTE, a Member's Guide, electronic mail and conferencing, training workshops and introductory seminars, an on-line catalog of resources available from suppliers, and searches tailored to special requirements. EDUNET has developed special software so that microcomputers such as the Apple II can access the large computers used by EDUNET suppliers.

EDUCOM Consulting Group. EDUCOM Consulting Group was formed in 1972 as a source of impartial advice on the use of computing and information technology in higher education. Consulting is available in four areas:

1. System Performance Evaluation.
2. Strategic Resource Planning.
3. Organization Planning.
4. Management Systems Implementation.

In 1978, with a grant from Eli Lilly, & Co., EDUCOM built the EDUCOM Financial Planning Model (EFPM). Users can build and operate budget models through a question-and-answer routine that requires no computer sophistication; access is via the EDUNET dial-in network.

EFPM now resides on a Cornell University computer. It is used by over 120 institutions. As of August 1981, it cost $2,000 per year ($1,750 for EDUNET members), plus $2,250 startup consulting ($2,000 for EDUCOM members), and from $8 to $20 per terminal hour. It is supported by user fees and grants. EDUCOM supports an EFPM Users' Group through a monthly newsletter and periodic meetings. Recent applications have been made in foreign higher education, in noneducational settings (the New York Public Library), and in the development of linkages for access by microcomputer.

Research and Development. Previous studies have addressed EFPM (described above), computing in small colleges, and the role of technology in library resource sharing. Of special interest is a 2-year study, completed in April 1981 for NSF, to identify factors affecting individual and institutional sharing of computer-based resources.

Budgets and Financing

The financing of EDUCOM is like that of other typical regional service organizations (RSOs).

> The typical RSO functions on a very tight budget with virtually no discretionary funds, and some proportion of continuing income derived from external funding agencies. With a tight budget, a small staff, and high reliance on volunteer efforts, the typical RSO is in a precarious financial situation. In order to offset financial instability, most RSOs rely on a mixture of revenue that includes membership fees and fees-for-service, as well as external funding.[1]

EDUCOM was incorporated with $1,000 privately donated by five faculty from five different medical schools. No public moneys were involved. It operated entirely on the basis of membership dues, fees for service, and volunteerism until 1972. Then, in the early 1970's, NSF sponsored three seminars and the development of a network simulation model. This led to the establishment of the Planning Council on Computing Education and Research. The council's activities were funded by grants from 20 EDUCOM institutions, with matching grants from the Ford, Carnegie, and Exxon Foundations. This funding was restricted to special activities and did not support day-to-day computing. In 1979, the council disbanded with the launching of EDUNET.

Additional funds have been granted by the Lilly Foundation to develop and maintain EFPM and by the Exxon Foundation to support computing relating to the law. Over the last 10 years, EDUCOM's total budget has changed, however, from over 50 percent reliance on outside grants to less than 10 percent. Membership dues and fees for service provide the large majority of its income. A tiny fraction is generated by TELENET discounts. Residual requirements are met by the current Lilly grant.

Future requirements for external support are expected to run between $50,000 and $100,000 per year. Thus, although EDUCOM has made significant progress toward self-sufficiency, its financial future is not yet secure. For example, EDUNET can balance its books only by drawing on a reserve fund established at its inception.

EDUCOM expects to receive progressively less support from the Federal Government, in part because of current Federal attitudes and in part because EDUCOM's own goals rarely match precisely the program interests of specific agencies. One successful strategy has been the solicitation of matching funds, preferably from private foundations. This approach assures consensus and commitment on the part of EDUCOM users, a sharing of the financial load, and isomorphism between EDUCOM goals and resources.

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[1] D. D. Mebane, "Computer-Based Resources Sharing in Higher Education," *EDUCOM Bulletin,* vol. 16, No. 3, fall 1981, pp. 27-32.

Industry-Based Training and Education Programs

The following discussions describe applications of educational technology in the corporate instructional programs of three companies. Examples have been drawn from the airline, high technology and tobacco products industries. Forms of information technology utilized by these companies include computer-assisted instruction (CAI), computer-managed instruction, computer-based simulation, video disk and teleconferencing.

High Technology

CAI is put to extensive use by a high-technology firm with corporate headquarters in the Northeast. The company has a large internal education group and an executive team that views training and education as an integral part of the product development and manufacturing process. Management instruction, technical training, and customer education curricula are developed centrally by the staff within this unit, but instruction is highly decentralized. Field training centers located in areas of good market potential, are the sites of most training for staff and clients. Computer-based instructional packages developed for use at these centers, are often distributed directly to corporate field offices for initial and refresher staff training.

Over the past few years, the company has experienced a severe shortage of college-educated generalists, a type of individual it had previously recruited to fill field-service engineering positions. Formerly, these individuals were given instruction in total systems design and, with access to engineering specifications, were expected to be fairly self-sufficient on field service calls. However, as the company's product line became more and more diversified, this approach to training and maintenance became unworkable.

At about the same time, the problems presented by classroom training on a fixed schedule, plus the ever-increasing travel and salary costs incurred while staff were receiving instruction, began to have impacts. Responding to these conditions, the company decided to revamp its recruiting program and training system for field-service engineers. A job analysis led to the development of three separate types of task-related instruction for three distinct types of hardware:

- terminals,
- small computer systems, and
- larger computer systems.

Having made the divisions, it was possible to lower educational recruitment criteria far below the bachelor's degree level for those to be trained to service terminals and small computer systems. (This was a major breakthrough, since the company employs some 16,000 field-service engineers worldwide.) CAI packages were developed in-house to reduce travel and salary expenditures of classroom training at the field-education centers. Field-diagnostic centers were established as backups to the new field-service structure, so that customers could contact experts knowledgeable in hardware and software design to diagnose the specific equipment malfunctions they were experiencing and to recommend their remediation.

This new training and maintenance system is paying off in a number of ways. The CAI system has proven to be very cost effective. It has enabled managers to weave training into existing work schedules, and has been more responsive to individual learning requirements. The new field-service organization has enabled the firm to overcome what was a severe personnel shortage and to keep customer service charges to a minimum. However, a technical education representative stated that the firm must continue to be aware of the limitations of CAI in that " . . . people can only use a linear system for so long before the learning curve is affected; they need contact with other individuals." He urges managers of individual installations to use the system with groups of trainees in a classroom setting for maximum effectiveness.

At present, no other forms of information technology are used in the staff education program. In the near future, there are plans to use video disk integrated with a microcomputer. Cable television and satellite communications may also be used in the technical education programs.

Tobacco Products Co.

As an outgrowth of technological change, a major tobacco products firm has established a unit within its information systems group charged with analyzing the potential uses of newly available technologies in production and support activities of the corporation, including training. As a result of this program, a project on applications of synthetic speech and voice recognition is under way;

Hughes Aircraft Co.'s Training and Maintenance Information System (TMIS) is being used for the first time on a corporate production line; CAI is being extensively employed; and, within the next few months, a teleconferencing network will be established.

At one time, TMIS was being used as a training and maintenance aid for the U.S. Army's tank maintenance technicians. Under contract to the Army, Hughes Aircraft had developed the device, which consists of a video disk unit integrated with a microcomputer. Its cathrode ray tube (CRT) is used to present text and digital graphics—often simultaneously. After seeing a demonstration of the system in the company's corporate training center and conducting a formal evaluation of its potential in the factory environment, the tobacco firm decided to contract with Hughes to develop two prototype units to train employees to maintain and repair cigarette packaging equipment (both mechanical and electronic maintenance). The two devices—approximately 4½ ft high, 2 ft wide, and 2 ft deep—were installed in 1978.

Initially, the company saw two distinct applications for TMIS. They planned to develop a training software package for classroom use together with one designed to run in the plant on the production line, where several units would be installed, to assist maintenance/repair personnel on an ongoing basis. They soon discovered that one maintenance/repair software package with "imbedded training" would work in both settings, but in practice still-motion mode (single frames) would be used in the factory.

An evaluation of the prototype units in the training center was conducted in 1979. The results were dramatic in terms of the time and money saved as compared with traditional classroom instruction. As a result, three devices that had been specifically constructed for placement in the industrial environment were ordered from Hughes. Installation of the prototype in the plant is now in progress and will be followed by an evaluation of actual production-line use.

Because of the successful use of TMIS, the company is now considering the use of video disk to archive office records and to create an electronic parts catalog containing simulations of equipment. Users would be able to walk around a particular item, focus on its component parts, and then—using the same system—ascertain the number and availability of the part. Recommendations have also been made to use video disks for management training.

Many uses of CAI may be observed throughout the company. For the past 3 years the company has used PLATO basic engineering and computer science skills to train factory and office personnel. It uses Apple computers to teach task-specific skills, such as those entailed in learning machine operations, where simulation can be a particularly useful learning device. Approximately 35 percent of all training is devoted to the retraining of existing personnel, a process necessitated by continual modernization and modification of factory equipment.

A considerable amount of new construction and expansion of existing plants is now under way, and a teleconferencing system designed to link these facilities with corporate headquarters is about to be installed. The company is already examining how this technology, although originally designed to monitor construction progress, can be applied to training.

Airline Industry

A major commercial airline has an elaborate training development system that consists of:

- a corporate headquarters-based program for sales, instructor, and management training;
- a corporate headquarters-based computer division training activity;
- a centralized flight training center, located at a major airport away from corporate headquarters; and
- a centralized maintenance training center, located at another major airport some distance from corporate headquarters.

Once the design phase is complete, sales, instructor, and management training may be delivered centrally (corporate headquarters) or at individual airports or ticket offices. A CAI group develops courses that are then used by airline staff via existing terminals to book reservations and related activities. Wherever possible, CAI is used for "straight knowledge transfer." For example, CAI development staff have devised courses on how to book reservations, compute fares, and carry out other tasks that are necessary in occupations such as that of a reservations agent, a passenger service agent, a storekeeper (airline supplies), a flight attendant, and airport operations personnel. Each time the airline's computer division develops a new application, lessons are developed centrally, and notices of their availability are distributed to all airports, ticket offices, and other locations, where management uses them to the extent that they apply to entry-level training and/or instruction of existing staff.

The airline would like to use the PLATO system in its management training program, but found it too expensive. Uses of satellite technology and telecommunications systems have been investigated, but costs have also precluded their use even though it is recognized that they are cost effective in the long run. Video disk technology has not been employed, nor are there any plans to use it in the future. Video cassettes are frequently used in management training to enhance traditional methods carrying out role-playing exercises.

Computer Division Training

The Deltac self-instructional video-cassette system is used by the computer division to provide technical training to programers, not for initial instruction but for professional development and upgrading. No other forms of information technology are currently being used.

Flight Training

Many applications of the PLATO system may be seen at the airline's Flight Training Center. A program for Initial First Officer training has been designed and tested, but little or no use has been made of it as yet due to current economic conditions within the industry. The company has also used PLATO in pilot training, and is now moving ahead with a Boeing 767 pilot training program to be developed *entirely* on PLATO. For the first time, this system will be used in lieu of flight simulators. Simulating various types of cockpit equipment, PLATO will give 767 pilot trainees a way to master these individual systems that is less expensive than using them in combination. Up to now, PLATO has only been used to substitute for the cockpit procedures trainer, a device that allows participants to practice certain processes after classroom instruction, but before flight simulator training.

The airline has also been investigating the use of video disks in conjunction with PLATO for flight training of visual effects and it may incorporate their use into the instructional package by the end of this year. Teleconferencing is being used to keep 767 course developers in daily contact with Boeing Aircraft engineers so that training designs may proceed in advance of actual aircraft delivery. (The airline also used teleconferencing for Boeing 747 design conferences.) While there are no plans to use satellite technology, a complete video tape production facility has just been installed at the Flight Training Center, which the manager of flight training hopes to use to develop instructional tapes for distribution to field operations at airports across the country.

Maintenance Training Center

All airline personnel engaged in maintaining airplanes and ground equipment either receive instruction at the Maintenance Training Center or are trained by means of video tapes that are produced there and then shipped to 56 maintenance stations (located at major airports). This is the third year that the airline has utilized video tape in developing maintenance training packages, at a rate of about 40 packages per year.

The manager of Training Support Services stated that the bulk of maintenance training is still carried out in the classroom by an instructor. Overhead projectors are used, as are slide-tape presentations that are developed by in-house curriculum specialists. Over the years, the airline has developed a number of computerized simulators for use in training airplane maintenance personnel, but high cost of simulators cannot be justified by the amount of use they get prior to delivery of a new line of equipment. After the planes are received, there is always sufficient "ground time" available for training.

Computer graphics are being investigated, since engineering drawings produced in the design phase are made available by airplane manufacturers on magnetic tape and their volume makes the use of manuals very difficult. However, cost may turn out to be the key obstacle here. The use of video disk technology has also been explored, but the manager of Training Support Services found it to be " . . . too costly to make that first disk . . . ," since his distribution network consists of only 56 maintenance stations. The cost of converting video tape to video disk is also a major prohibiting factor.

Information Technology and Libraries

The library—an institution that acquires, manages, and disseminates information—both provides educational services and serves as an educational resource. Information technologies offer libraries unique opportunities and capabilities for enhancing their current services and for extending them to new areas—particularly if, "The task of the library is to consider itself an institution for allowing people to utilize information."[1] Consequently, the advent of the information revolution could alter both the way libraries operate and their role in society.

Findings

- Information technology has changed the operation and user information programs of public, special, and academic libraries.
- Utilizing information technologies for operational programs can make libraries more productive and efficient and allow them to devote more resources to other programs—e.g., user services.
- Information technologies permit a library (sometimes called an information center) to greatly expand its resources. Networks, on-line information services, and cable services permit the sharing of materials and provide access to information in a way that was not previously possible.
- Libraries may be the only way that certain members of society can gain access to information technologies and to the information that these technologies provide.
- Libraries that fail to adopt these new technologies for information services many risk becoming irrelevant.

Libraries and Information Technologies

Use of information and communication technologies has affected all aspects of library services. Software is now commercially available for practically all aspects of *library operations:* circulation, inventory, acquisitions, periodicals, cataloging, and reserves. The use of the technologies for *information user services* has resulted in the formation of library networks and in the ability to access national data bases, thus allowing faster and more efficient access to information.

Programs oriented both to operation of the library and to user needs are critical for fulfilling a library's mission. For instance, an on-line acquisition system can reduce the ordering and receiving time for a new library purchase, thus providing patrons with the desired material in a shorter time. Circulation, cataloging, and other automated library systems offer similar benefits. One example of a commercially available system for library operations is the Automated Library Information System. This system can support many of the operational procedures in a library and is fully integrated.* Its many uses range from charge and discharge functions to cataloging and the maintenance of master holdings.

Networks

Two or more libraries may form communication networks utilizing information technologies to enhance the exchange of materials, information, or similar services. The formation of local, regional, and national networks has already significantly altered the operation of libraries.

The IRVING Network. When fully operational, the IRVING network in the Denver-Boulder, Colo., area will use communications technologies to link the library systems of Aurora, Boulder, Littleton, Denver, and Jefferson County in order to enhance their current capabilities. Each of the library systems employs different automated systems and in some cases different library operations procedures. Connecting these heterogeneous data bases, this new communication link will allow shared cataloging, more efficient interlibrary loans, shared acquisition, enhanced development of special collections, circulation within the entire system, an electronic message service, a reference information service, access to administrative data, and increased access to special collections (e.g., Denver's Western collection and Jefferson County's Asian collection.)

To date, no such system exists anywhere in the United States. This network, designed to expand beyond the current five systems to accommodate up to 30 other libraries, could serve as the foundation for the larger, automated, statewide network now under consideration.

The planning for IRVING was made possible through a Library Services Construction Act (LSCA) grant, and its implementation was funded by the Colorado Board of Education. Studies identified a distributive configuration as the most effective system for transmitting electronic data among the libraries in an interactive, on-line mode. Conventional analog service from Mountain Bell was chosen as the transmission media. The distributive option will require a smaller investment initially than would other alternatives (e.g., the use of public packet switching using public networks accessed via telephone links). Moreover, software for such a system will be easier to develop and maintain. This approach also permits the separation of the operation and the control of the network by allowing each participating library to be responsible for the operation of its own system.[2]

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[1] M. Turoff and M. Spector, "Libraries and the Implications of Computer Technology," proceedings of the AFIPS National Computer Conference, vol. 45, 1976.

*A system which is fully integrated is one in which the individual procedures operate in support of the other system procedures.

The CARL Network. Through the Colorado Alliance of Research Libraries (CARL) network, seven research libraries will share an on-line public access catalog reflecting the holdings of all institutions. Six of the CARL members are academic libraries; the seventh is the Denver Public Library, which, as members of both IRVING and CARL, expands the network. The holdings of these libraries represent 47 percent of the total collections and over 90 percent of the unique items in the State. Once these holdings are on-line, a user will have to search only a single public catalog rather than seven. Creating a single on-line catalog for these institutions will require modifying many operating procedures to comply with common formats, common records, and a common data base.

The University of Colorado at Boulder, the Colorado State University, the University of Northern Colorado, the Colorado School of Mines, the Auraria Complex, the University of Denver, and the Denver Public Library have established a nonprofit organization to create this new research resource within the State.

As in the IRVING Project, LSCA funds were used for the initial planning efforts. Currently, moneys from the seven institutions; DataPhase Systems, Inc.; and Tandem are being used to complete the project. Two-thirds of CARL is now complete. Testing will begin by the summer of 1982; implementation is scheduled for the following fall. Once the public-access on-line catalog is in operation, member libraries intend to investigate electronic delivery of materials between their institutions.[3]

The OCLC Network. On-line College Library Center (OCLC) network is an example of a major computer-based cooperative network that is employed by all types of libraries nationally and internationally. The OCLC network allows libraries to acquire and catalog materials, order custom-printed catalog cards, initiate interlibrary loans, and locate materials in member libraries (2,500) and more. Through dedicated, leased telephone lines, members access OCLC services on specially designed terminals, through dial- access terminals utilizing the TYMNET telecommunications network, or by direct dial. The OCLC On-line Union Catalog contains over 7.4 million bibliographic records in MARC (Machine Readable Cataloging Format). If a library identifies an item of interest, OCLC produces presorted catalog cards. Also available are accession lists of newly cataloged materials for microform catalogs, circulation records, and selected dissemination of information (SDI).*

On-line Information Services. The increasing inventory of literature and information is making it almost impossible for a user to keep up, let alone to catch up. An example of the explosive rate of information growth can be seen in the areas of chemistry and chemical engineering, where the rate of literature growth can be tracked by the number of papers abstracted in the publication, *Chemical Abstracts*. For the 10-year period from 1961 through 1970, the rate of increase was 8.4 percent; during the 5-year period from 1971 through 1975 it more than doubled, to 16.9 percent. The recent increase has been even more dramatic—4.6 percent annually from 1976 through 1980.[4] This rapid expansion of information has also taken place in many other fields, such as medicine, law, and computer science.

On-line services such as national bibliographic data bases (e.g., DIALOG and BRS)—which are computerized retrieval systems covering a wide array of continually expanded subject areas—will make it possible for libraries to offer their patrons rapid access to a variety of information sources at relatively low cost. For example, PATSEARCH/Video PATSEARCH, contains information on 800,000 patents heretofore available only in the U.S. Patent and Trademark Office files in Washington, D.C., on microfilm, or piecemeal through other data bases. The advantages of on-line services are listed in table A-3.

Maggie's Place: Pikes Peak Regional Library District. On-line community information and referral programs are being explored and instituted by some libraries as a concomitant of their access to national information sources and the resources of other libraries and information services. The Pikes Peak Regional Library District in Colorado, for example, has developed *Maggie's Place*, a community information resource, which consists of computerized local and regional information of interest to its patrons. Users can access on-line all of the career and recreational adult educational courses

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[2] S. Hartman, IRVING Coordinator, Boulder Public Library, Boulder, Colo., February 1982.

[3] W. Shaw, Executive Director, CARL, January 1982.

*SDI is the selection and dissemination of information of specific interest to a library patron.

[4] D. B. Baker, "Recent Trends in Chemical Literature Growth," *C&E News* 59(22):29, June 1, 1981.

Table A-3.—Advantages of On-Line Services

Advantages of on-line services:

- Produce results very quickly
- Are cost effective
- Can be used for most types of searchers
- Can search fields (or data categories) for which there is no printed index
- Have the capability for searching very complex and elaborate strategies
- Offer the opportunity for increasing completeness of coverage through searching of multiple sources
- May contain information more current than available in the corresponding printed index
- Can be easily updated on demand or at regular intervals
- Permit any amount of strategy broadening, narrowing, or changing
- Causes less fatigue per search and reduces searcher's errors
- Require very little space for operation
- Save staff time
- Some kinds of data are retrievable only on a computer system
- Many more types of information can be searched on-line than in a manual system
- Material can be ordered with a simple command and charged to an account—a copy on demand service

SOURCE: Office of Technology Assessment.

available in the region through this program. Similarly, information is available about day-care centers, clubs and other community organizations, social services, and a matching carpool data base. The files are available both in the library and to approximately 500 members of the community and businesses with access to terminals.

Programs developed and in use at Maggie's Place include those for library resources, networking, and community resources. The library resource files are automated programs that relate to the operational needs of the library such as circulation, reserves, and acquisitions. Networking files give the user access to State and national information resources, such as DIALOG, BRS, ORBIT, RLIN, GIS, COCIS, and The Source.[5] The community resource files contain on-line information of interest to members of the Colorado Springs community. Currently, they include five files: calendar, day care, clubs, courses, and carpool. All of these are available for use in the library or in homes or businesses via telephone lines.[6]

Maggie's Place, compared with other public libraries, has a number of unique features. First, the amount of automation is unusual. A substantial investment has been made by the library district for this effort (almost $400,000 since 1976). Yet, despite the initial large investment, savings have been high—over $500,000. Second, the community resource files are the only such files in the Nation. Beneficial to librarian and user alike, they are a central and easily accessible source of the kind of information frequently requested. They demonstrate that information technology can assist both the operational needs of the library and the resource needs of the patrons.

Third, by making the library's programs accessible to outside users (over 500 presently), the library has expanded its capabilities for community use and utilized the information technology to its best advantage. And last, through the use of the technology, Maggie's Place offers all users access to information resources.

Microcomputers in the Library. Many libraries are considering installing a microcomputer on a coin-operated basis. Recently, several firms have begun to actively market such services to public libraries across the country. For example, in a contractual arrangement with Copy Systems, Inc., and CompuVend, a TRS-80 was installed in the Tredyffrin Public Library near Philadelphia. The computer is available for patron use at a cost of $0.50 per 15 minutes. The company is responsible for the operation and the maintenance of the equipment and has provided 24 Radio Shack program tapes, manuals, and workbooks on BASIC language and programing.

Library patrons may use the terminal for homework, statistical manipulation, learning how to program, playing games, and work. Children and teenagers appear to be the predominant users (65 percent), although this is expected to change in the near future. Average use of the microcomputer has been 2 to 4 hours per day, 7 days a week. Based on such community response, a computer with a larger capacity will be installed shortly. The new system will provide access to The Source and will attempt to satisfy the computing capacity requirements of the local business community. New program tapes such as Visicalc will be supplied.

With this arrangement the library uses the technology as an informational and educational resource. In addition, the library makes it possible for all those who do not have access to this technology in their homes or in their businesses to become familiar with computers and to have access to the valuable information resources they provide. The library also benefits in a number of ways: limited staff time is involved; the library is not responsible for operation and maintenance of the equipment; no financial burden is placed on the library (e.g., purchase of the equipment); the equipment will be updated to reflect changes in the technology and to reflect market needs in the community; step-by-step instructions allow the user to use the microcomputer with little, if any, assistance from a professional; and, thus, no extra staff training is necessary.

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[5] DIALOG: Lockheed Missiles and Space Co., Inc.; BRS: Bibliographic Retrieval Service, Inc.; ORBIT: System Development Corp.; COCIS: Colorado Career and Occupational Information System; RLIN: Research Libraries Information Network; GIS: Time Share Corp.

[6] K. Dowlin, Director, Pikes Peak Regional Library District, February 1982.

Other examples of microcomputer use include the following:

- The Clinton-Essex-Franklin Library System in upstate New York has installed a microcomputer for use by patrons. The decision was prompted by concern on the part of the librarian that patrons, particularly children, were neither familiar with computers nor had access to the technology. Although the microcomputer was installed in the Children's Room, it is available to adults as well. Volunteers have been teaching computer programing, and librarians believe that, based on its usage, the overall program is an overwhelming success.
- A cooperative effort has been initiated between the San Bernardino City School District, Calif., and the public library to assist students in preparing for proficiency tests. Microcomputers in three of the city's library branches provide CAI in mathematics and in the language arts. A queuing system allows high school students to be first-priority users through June 30, 1982. Other library patrons have access to the terminals that are not being used by students.
- The public library in Providence, R.I., has installed INFORM, a system whose uses range from bibliographic instruction to the use of audiovisual equipment. INFORM is regarded as an on-line library guide or handbook that also includes updated information on community events and agencies. Its touch-sensitive terminals are available with graphic and textual capabilities.
- Groups of school librarians in the St. Louis, Mo., area have developed a series of self-instructional programs for the Apple II that are user guides for periodical indexes and almanacs, *Bartlett's Familiar Quotations, Current Biography,* and poetry indexes. The programs are aimed at the secondary school to adult levels.
- The St. Luke's Hospital Health Sciences Library in Missouri has instituted a wide range of programs on an Apple II Plus computer. Current programs include, among others: recordkeeping and reporting for nurses, continuing education classes, an "intelligent" terminal for on-line searching, nutritional assessment of intensive-care newborns, audiovisual inventory listing, and the logging and analysis of on-line searching records.

The provision of such services raises new questions for participating libraries. Where should the terminals be located. Should provisions be made for privacy? What type, if any, of collection development should the library engage in? Should the library sell disks for patron use? Should there be a scheduling or reservation system or should patrons use the computer on a first-come first-served basis?

Cable Services and Video Facilities. With the expansion of cable franchises nationwide, an increasing number of libraries are exploring the potential of cable for delivering library services. Many libraries have employed video capabilities for years, but the addition of cable services in a community has expanded the library's resource base. The most extensive users of cable and video are junior and community colleges and public libraries. The former rely on cable services as a means of delivery, production, and housing of course materials; and the latter, for expanding the library's role as a community information resource center.

Generally, junior and community colleges, because they are relative newcomers to the academic scene, are most actively involved in video programing and cable services. Many colleges constructed during the 1960's and early 1970's incorporated video capabilities in their library facility or plan. Older research institutions and libraries, on the other hand, generally cannot afford to invest in video facilities nor to adopt their current structures to include such facilities.

The Division of Learning Resources at the Greenfield Community College in Massachusetts is an example of a community college library that has integrated video capabilities with local cable services. The library houses both commercially available video tapes and faculty/student-produced products. Students in conjunction with the Learning Resources Center and the local cable franchise produce weekly cablecasts for the community.

The Monroe County Public Library in Bloomington, Ind., is an example of a local public library actively involved in all aspects of cable and video services. The library has cablecast 3,000 to 4,000 programs a year (or 60 to 64 hours of programing per week) to the community on Community Access Channel Three. Half of the local subscribers (90,000) watch programs on Channel Three. Also 38 percent of the subscribers noted that local programing was a primary reason for initiating cable services.

A wide range of programs are offered and produced by the library. Some programs, such as "Kids Alive," are produced by children with assistance from the library staff. Local teachers, trained by library staff, allow the equipment to be used for many school activities. City council meetings are regularly cablecast; and special-issue programs, about housing and the elderly, for example, are presented.

Because of its active involvement in cablecasting, the library and Channel Three have been asked to participate in the refranchisement process. Library involvement in this process is common and occurs frequently. In fact, in franchise proposals library needs and desires are solicited by the bidders. Some of the programs developed at Maggie's Place will be used at other libraries as a result of cable awards.

Implications of Library Technology. Approximately 10 percent of the libraries of the United States have some form of automated capabilities, and an increasing number of libraries are exploring the possibilities of these technologies. On-line information retrieval services and provision of information technologies enhance the traditional services provided by libraries but also raise important questions of cost. For example, can a library afford to run searches for patrons on DIALOG free of charge? Can it afford to use these national bibliographic data bases, which require trained searchers, and entail cost ranging from $10 to $150 per hour? Such costs place an added financial burden on public as well as on academic and special libraries. For some libraries faced with reduced funding from State, Federal, and local sources, the price of the technology may be particularly burdensome. However, by not providing these services, libraries may prevent people from finding and utilizing the information, a situation contrary to the traditional role of libraries in society. (Furthermore, it has been suggested that when libraries provide these services and develop community resource files they become competitive with private information vendors.)

Such concerns are particularly relevant to a reconsideration of the role of public libraries in an information society. At present, libraries provide access to information and knowledge to all users free of charge, but it is questionable whether they will be able to continue to do so. One role proposed for libraries incorporates and reflects societal change. This role would entail:

- providing access to complicated or seldom used data bases;
- providing community conferencing and message center programs;
- providing on-line access to information or library resources;
- providing access to community data and community information locations for referrals;
- providing access to resources in other libraries via networking;
- providing access to high-demand information and materials via computer or video disks; and
- providing access to electronic resources for those who cannot afford home computers or terminals.[7]

Museums

Findings

- More and more museums are incorporating information technology, particularly computers, into both their exhibits and their educational programs. The technology is used for operational purposes and to provide computer literacy and related courses.
- The introduction of the technology to museums is altering the role of these institutions. This change is especially evident in the recent establishment and success of childrens' museums across the country.

Museums, like libraries, provide important educational services. Since the establishment of the first public museum in 1743, museums have exerted a strong influence on U.S. culture. They function as repositories for conserving the world's culture and for relaying it to present and future generations.

Beyond the overall educational nature of their exhibits, most museums conduct and provide additional educational services. Recently, more and more have incorporated information technology, particularly computers, into both their exhibits and their educational programs. They are used generally for operational purposes and to provide computer literacy and related courses. The delay in acquiring information technology until only recently, has been primarily due to the fiscal constraints common to most museums, which operate on a limited budget and depend on donations that can fluctuate from year to year.[1]

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[7] Ibid.

The Use of Computers

Computers are generally used for four purposes: for interactive exhibit devices, for exhibit control, for administration, and for education programs. All have educational applications.

Interactive Exhibit Devices. Museums use computers and related technologies to increase the attention span and alter the traditional experience of the typical patron. It is possible, for example, to increase a viewer's attention span from 10 seconds to 3 to 10 minutes, a significant improvement that has enormous implications for how a museum can present information. Examples of exhibits range from instruction on how to use a computer to using a computer to calculate quickly the nutritional value of a meal. Simulation programs are widely utilized, although these are also the most difficult to create.

Incorporating computers into an exhibit presents some special problems not generally encountered with other media. The exhibits must be appealing in order to attract users, but the programs must be relatively simple, since most users are unfamiliar with the technology. Furthermore, such programs must be able to contend with repeated mistakes, constant use, and even abandonment by the patron.[2] Thus, developing programs suitable for a museum environment involves considerable skill.

Exhibit Control. The control of exhibits by computers has a number of advantages: 1) cost and maintenance are reduced because of fewer components; 2) additional features can be added at minimum cost; 3) control devices can be standardized from exhibit to exhibit; 4) the potential exists to customize a patron's experience; and 5) computers permit greater flexibility in altering an exhibit at relatively low cost.[3]

Administrative Uses. Computers are largely used for such standard purposes as word processing, accounting, updating mailing lists, recordkeeping, collection management, and inventory.

Education Uses. During the past 10 years several museums have introduced computer literacy programs and computer labs. Offering these courses is a natural extension of previous and ongoing educational activities within museums. And, as with libraries, the availability of such programs makes it possible for users to become acquainted with this technology in a nonthreatening environment in which there is no pressure to succeed or fail.[4]

The Hands-On Approach

The Lawrence Hall of Science. In general, museums that provide programs in computer literacy have adopted a hands-on philosophy. This principle was first initiated at the Lawrence Hall of Science in Berkeley, Calif., in 1972, when an exhibit entitled "Creative Play With Computers" was introduced. The exhibit used the university's timesharing system and teletypes. Since then, this program has been expanded to include a computer laboratory, and computer technology is used extensively throughout the exhibits. The computer laboratory has 30 microcomputers that can be used for computer literacy programs or individual programing by anyone 8 years or older. The Hall of Science also operates the Science Shuttle, which transports microcomputers to local schools for computer literacy and related classes. The Science Shuttle has greatly increased the access to computer technology by local school-age children.

The Capitol Children's Museum. Newly established in Washington, D.C., the Capitol Children's Museum is a learning center with a strong emphasis on communication. The most recent addition to the facility, the communications wing, traces the growth and development of communication throughout human history. Like the Lawrence Hall of Science the museum uses the hands-on approach in all of its exhibits. Similarly, the museum has a computer classroom, the Future Center, with 20 microcomputers.

A visitor to the museum's communications wing is introduced to communication through a sound and light show held in a model of a 30,000-year-old cave. The cave depicts the earliest type of communication: drawings of man's experience with hunting and tools. Further developments in the forms and means of communication are shown through a wide range of exhibits: torches used by the Greeks to relay messages, drums used by African tribes to relay messages via different sound patterns, and a variety of written forms—alphabets and hieroglyphics. In addition, other ways to communicate such as Braille, Morse code, pig latin, and sign language are shown. Many of the more recent types are demonstrated by means of video tape players or microcomputers.

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[1] R. King, Director of Exhibits, Boston Museum of Science, February 1982.

[2] D. Taylor and D. Rhees (eds.), *Survey of Computer Use in Science-Technology Museums* (Washington, D.C.: Association of Science-Technology Centers, 1981).

[3] Ibid.

[4] P. Hirschberg, Coordinator, Communication, Capital Children's Museum, April 1982.

The wing also contains telecommunication devices. For instance, there is a fully equipped radio studio available for use where children can produce and tape messages for their own use. There are future plans for a comparably equipped television studio. Also, there is a scale model of a satellite dish inside the museum that replicates the museum's communication satellite dish which can receive up to 40 cable channels.[5]

The Future Center is a classroom equipped with 20 Atari 800 microcomputers complete with printers, disk drives, and color monitors. Its purpose is to introduce new users to microcomputers and to allow previous users access to the technology. The center thus makes available to everyone both the technology and the skills and information it provides. The courses offered range from those designed to assist teachers who are unfamiliar with the technology to become computer-literate to those to introduce children to the technology. Schools that do not have microcomputers can schedule class visits on a regular basis.

The courseware are combinations of programs developed by the museum staff and software donated by Atari. For example, PAINT, a software and book package, allows the user to create paintings on the Atari, while using a variety of learning skills as well as learning about and exploring the microcomputer. For more experienced users there are courses in programing BASIC. Because obtaining quality software is a major problem, the staff of the museum is actively engaged in design-

In the Capitol Children's Museum, Washington, D.C., a visiting primary school teacher works with her students as they become computer-literate. Schools from throughout the Washington area utilize this facility to introduce their students to the world of comput[illegible] any schools enroll their students in a special series of classes designed to e[illegible]ce their primary and secondary education ing and developing software for the Future Center's constantly growing and enthusiastic clientele.

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[5] Ibid.

As a nonprofit institution, the Capitol Children's Museum relies on corporate donations and grants to continue its operations and to develop new exhibits and educational services. The majority of the museum's equipment has been donated by private companies; e.g., the satellite dish by Scientific Atlanta, the microcomputers from Atari, and a PDP 11/70 and supporting hardware (printer, video terminal, and disk pack) from the Digital Equipment Corp. (DEC), to name just a few.

The recent gift of a minicomputer by DEC represents a significant contribution to current museum services, but more importantly to future potential. Once operational, the PDP 11/70 will be able to interconnect all of the museum's exhibits, thereby increasing the control over their use. It will also provide an internal tracking and information system of exhibit users—how many visitors utilize what exhibit for how long, and so forth.

In the long term, the computer will be the basis for Kid Net, a time-sharing system that will be both an internal and external network. Internally, the system will facilitate such activities as electronic mail, games, and demonstrations. Externally, the network will be connected with other Washington-based institutions such as local schools and Congress and will possibly tie in with other children's museums such as the one in Boston. Other long-term possibilities include a national electronic newsletter.[6]

The Use of Video Disks

Several museums are experimenting with video disks for storing and preserving collections. Because they are both very new and very costly, few museums, have employed this technology. However, the video disk's features make it uniquely suited for collection manegement: large amounts of material can be sorted; materials don't deteriorate; researchers are not dependent on original materials; and the content of a museum's collection of photos, slides, or art can be sent for viewing to other institutions around the world.

The Smithsonian Museum of American History is placing some of its collection of (30,000 to 38,000) slides and photographs on a video disk. This measure will ensure the life of this combination of materials since most of it is fragile and subject to damage from repeated use.[7] In a similar project, the National Air and Space Museum is placing some of its photograph collection on video disks and interfacing the disks with the museum's computer. The museum also has an interactive video disk which allows patrons to design an aircraft.[8]

The National Park Service (NPS) of the Department of the Interior also uses video disk technology. NPS originally used video tape players at many of its visitor centers. However, the initial high cost of purchasing the equipment, plus the high rate of failure, maintenance costs, and tape breakage, led to initiating trials of video disk technology. Several video tape players have since been replaced by video disks. NPS is also considering video disks for use in collection management for reasons similar to those of the Smithsonian American History Museum. If collection management of selected projects at NPS is implemented, the disk would provide access to a variety of educational materials.

Military Uses of Information Technology

Findings

- All branches of the military have made substantial investments in research and development (R&D) on applications of information technology to education.
- The Department of Defense will likely be the only Federal agency likely to make major investments in R&D projects with educational applications.
- Educational uses of information technology have focused on two areas: training and basic skills.
- The need for a very large investment in basic skills training by the military, $56 million in 1979, is an indication to some that the public schools are not providing an adequate education.
- Many of the projects initiated by the armed services could be transferable to the civilian sector, although there may be barriers to transfer. Considering the large investment made by the armed forces in information technology R&D, it would be useful to establish a mechanism whereby potentially transferable projects could be identified and barriers to transfer removed.

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[6] Ibid.

[7] J. Wallace, National Museum of American History, Smithsonian, May 1982.

[8] H. Otano, Chief, Audio-Visual Systems, National Air and Space Museum, Smithsonian Institution, May 26, 1982.

Fort Gordon Signal Corps Training Center, Fort Gordon, Ga.—in former days, Ft. Gordon students would get 12 minutes of "hands on" instruction at this $7 million satellite down-station. The rest of the classroom time was spent in costly waiting. But with the new information technologies, instructional time has increased fivefold

The military has been a leader in the development and use of instructional delivery systems having used high technology for many years. Its great need for technical skill training, together with the critical nature of its national security mission and its nonprofit orientation, has led to a training technology revolution and a good market for state-of-the-art technology in military education and training.

Interested in new methods of training that improve efficiency, reduce training costs, and increase the effectiveness of training, the military has turned to information technology for solutions to some of its educational and training problems. The armed services need people in operational assignments. By advancing and applying state-of-the-art technology in training, they hope to turn out quality individuals sooner for operational job assignments.

In addition to supporting improved general and specific military skill training, the armed services also support basic skills training. Military jobs demand basic skills equal to or greater than those of civilian jobs.[1] Many current recruits lack competency in basic skills, a situation that has important implications for the operation of sophisticated technology and that has led to plans to increase, improve, and automate technology training programs. Anticipated manpower shortages undoubtedly will necessitate the enlistment and subsequent training of individuals of less aptitude, thus placing even greater emphasis on programs for instruction in basic skills.

As the largest education and training institution in the Nation, the military constitutes a large and viable market for training equipment, programs, and services. In fiscal year 1982, for example, approximately $10.5 billion will be spent on individual training. The training of individual officers and enlistees is differentiated from the training of operational combat units, and individual training can be broken down into a number of categories. Indoctrination and basic training for approximately 338,000 students will cost $822 million, while approximately 709,000 students will receive specialized skill training for military jobs at a cost of $2.4 billion.[2] (See table A-4.) In fiscal year 1982, approximately 236,500 student man-years will be spent at training schools.

The Department of Defense (DOD) now spends about $267 million for R&D on training and personnel systems technology, with $181 million or 68 percent of this for R&D on simulation and training devices and education and training.[3] (See table A-5.) The three service laboratories primarily responsible for military education and training research are: The Army Research Institute for the Behaviorial and Social Sciences (ARI); the Navy Personnel Research and Development Center (NPRDC); and the Air Force Human Resources Laboratory (AFHRL). The number of instructional technology R&D work units by major categories in operation as of April 1981 is estimated in table A-6. While all of the categories listed receive ongo-

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[1] G. Sticht, *Basic Skills in Defense* (Alexandria, Va.: Human Resources Research Organization, Final Draft Report, November 1981).

[2] J. Orlansky, "Techniques for the Marketing of R&D Products in Training," paper presented at the Society for Applied Learning Technology, Warrenton, Va., February 1981.

[3] Ibid.

Table A-4.—Number of Students and Cost of Various Types of Individual Training, Fiscal Year 1982

Type of training	Number of students in thousands	Cost in millions	Approximate in thousands per study
Recruit	338	$822	$2.4K
One-station unit training (Army)	104	322	3.1
Officer acquisition	16	313	19.4
Specialized skill	709	2,382	3.4
Flight training (basic flying skills)	6	1,458	229.7
Professional development education (e.g., military science, engineering, management)	32	330	10.2
Medical training	—	276	—
Support, management, travel, pay	—	4,618	—
		$10,521M	

SOURCE: Military Manpower Training Report for Fiscal Year 1982.

Table A-5.—Cost of R&D in Training and Personnel Systems Technology, in Thousands of Dollars, Fiscal Year 1982

	Army	Navy	Air Force	Total
Human factors	$17.6	$ 14.1	$14.4	$ 46.1
Simulation and training devices	24.2	107.1	17.5	148.9
Education and training	13.4	11.8	6.6	31.8
Manpower and personnel	9.0	19.0	12.0	40.0
Totals	$64.2	$152.0	$50.6	$266.8

SOURCE: J. Orlansky, "Techniques for the Marketing of R&D Products in Training," paper presented at the Society for Applied Learning Technology Warrenton, Va., February 1981.

Table A-6.—Number of Ongoing Instructional Technology R&D Work Units By Service and Department of Defense Total, April 1981

	Service			
Technology	Army	Navy	Air Force	Total
Simulation/games	26	49	68	143
Instructional system development	51	59	25	135
Training management	26	14	10	50
Learning theory	13	18	11	42
Computer-based education	13	16	9	38
Basic skills	2	4	—	6
Voice technology	—	3	—	3
Video disk	—	2	—	2
Artificial intelligence	—	1	1	2

NOTE: Inclusion of work units into the categories in the table are fairly arbitrary and are based on work unit titles. The absolute numbers of work units listed are approximations of service R&D efforts as of the date of directory publication. It should be noted that this enumeration does not consider *size* of the work units, only number of work units cited.

SOURCE: *Directory of Researchers for Human Research and Development Projects* (Washington, D.C.: Office of the Under Secretary of Defense, Research and Engineering), pp. 7-43.

ing support, high-technology simulation and the development of instructional systems and capabilities for more efficient and effective training appear to receive the most emphasis.

Interservice coordination shows potential for minimizing duplication of research efforts and funds. The Office of the Under Secretary of Defense for Research and Engineering is currently building a management information system that will document all of DOD's training research to include funding levels. This system, Manpower and Training Research Information System (MATRIS), will be fed into the Defense Technical Information Center (DTIC).

Comparison of Military and Civilian Education

In considering educational needs, distinctions can be made between the civilian and military education sectors, differences which influence the nature of education programs introduced. Some of the similarities and differences between military and civilian education and training are:

- The military educates and trains personnel within a more restricted age, sex, and range of ability; typically, military enlisted trainees are 18- to 21-year-old males with a high school education.
- Military personnel are paid their salaries while in training. Thus, instructional procedures that reduce training time and increase opera-

tional assignment time can assist in reducing training costs.

- Within the civilian sector, vocational education, job training for business or industry, and nonmilitary Government training are generally more similar to the military's educational goals and priorities than is education in elementary and secondary school systems.
- Measures of effectiveness may vary between the military and civilian institutions. Military research on computer-based instruction, for example, has emphasized saving student training time while maintaining constant achievement. Nonmilitary research generally emphasizes increasing the amount of achievement while keeping the length of courses constant.

Computer-Managed Instruction

In computer-managed instruction (CMI), learning takes place away from the computer. The computer scores tests, interprets results, advises the student what to do next, and manages student records and administrative information.

Advanced Instructional System. The Air Force's Advanced Instructional System (AIS) is an example of a military CMI system. It is a large-scale, prototypical computer-based education system installed at the Air Force Technical Training Center, Lowry AFB, Denver, Colo. The present version consists of 50 student terminals, 11 management terminals, and a CDC CYBER 73-16 computer that can support up to 3,000 students a day in four courses: inventory management, material facilities, precision measuring equipment, and weapons mechanics. These courses were selected to represent a cross-section of the technical training courses at Lowry, and they serve about 25 percent of the base's student body. Management terminals provide computer-assisted instruction (CAI) services for use by instructors (for developing or revising lessons and for retrieving data collected by the system). The system could be expanded to provided CAI services to students.

The AIS was designed with two objectives in mind: 1) to develop and implement an individualized, computer-based training system in an operational military training environment; and 2) to provide a testbed for computer-based educational R&D. It includes over 700 student carrels and 500 media devices that permit the instructional delivery device (sound-slide, filmstrip, programed text, etc.) to be adapted to the individual student. For example, a slow reader might learn more efficiently via audiovisual presentation rather than via printed text. With instructional content duplicated across delivery media, the computer assigns material and devices according to student aptitudes and preferences, as well as by resource availability. The actual allocation of media in the AIS is 55 percent printed materials, 35 percent audiovisual presentation, and 10 percent CAI.

The AIS computer provides three main support functions: 1) administration and management (resource allocation, materials development, recordkeeping, and report/roster generation); 2) instruction (student predictions, individual and team lesson assignment, test scoring, and delivery of instruction); and 3) data analysis/research (automatic data accumulation, sampling capability for statistical analysis, and standard statistical analysis programs). The computer thus takes over the majority of the managerial functions of the instructors, permitting them to concentrate on individual student instruction.

Many measures were used to evaluate the AIS, including costs, student and instructor attitudes, attrition rates, and the ratings of AIS students in their post-school jobs. In most cases, comparisons were made between AIS students and pre-AIS students in the same courses. Cost savings estimates were made by the Air Training Command manpower accounting personnel.

AIS results have been documented in several technical reports issued by the Air Force Human Resources Laboratory. In general, AIS students' achievement have been equal to or greater than non-AIS students—with net time savings of 15 to 40 percent, depending on the course evaluated. Maximum savings have been achieved in the lower-level, routine courses. Overall cost analysis shows that the system was totally amortized by January 1979, in a period of only 2½ years. This complete recovery of costs through savings in student instructional time is particularly noteworthy considering the extensive R&D costs included for research purposes. The AIS suggests that large-scale implementations of CMI would be cost effective.

Student attitudes were clearly very positive. The students felt that they had more opportunity to talk individually with their instructors than in conventional courses (61 percent), that the self-paced instruction was a good use of their time (77 percent), that they preferred AIS instructions to lectures (55 percent), and that the instructors were available whenever they needed them (73 percent).

Instructor attitudes, on the other hand, tended to be negative in general. They felt threatened and missed the ego-bolstering lecture method. Course attrition rates overall tended to rise slightly through the first 5 years of AIS implementation from a pre-AIS baseline of about 4 percent in 1974 to slightly over 5 percent through 1978. Attrition rates, it should be noted, are very sensitive to policy changes. The supervisors of AIS graduates reported satisfaction with their performance. The ratings of AID graduates were significantly higher than comparable ratings of pre-AIS students. A sample of 199 supervisors rated the performance of their AIS graduates as follows:

Excellent	25 percent
Very Satisfactory	34 percent
Satisfactory	37 percent
Marginal	4 percent
Unsatisfactory	0 percent

Overall, the AIS appears to be a successful, large-scale implementation of CMI. McDonnell Douglas Corp. is currently modifying the system to be transportable, to operate on smaller computers, and to be marketable to the Canadian armed services and to U.S. civilians.

Job-Oriented Basic Skills Training

Schools traditionally have 12 years to equip students with the level of skills necessary for them to function as adults in jobs or in further education. For the most part, schools are successful in their approach to imparting necessary basic skills for adult life. Fewer than 10 percent of those who have completed 12 or more years of schooling are severely deficient in their application of skills to practical tasks, as estimated by a 1975 adult performance level study.[4]

However, a substantial number of people either do not complete 12 years of school, or do so without gaining the requisite mastery of necessary basic skills for adult life or career performance. The services have had to cope with the critical problems presented when large influxes of poor readers entered the armed services, for instance, during Project 100,000. The traditional approach to remediate the problems of adults with insufficient basic skills for career success has been a continuation of the school general-literacy program.

However, traditional literacy training by the military has not been demonstrably successful. The most direct way to ensure that an individual can cope with specific military skill applications (to cope with a military career or environment) is to teach these applications or ones as similar to them as possible. For these reasons, the military has sponsored R&D leading to a technology for job-oriented basic skills or remedial literacy training.

A considerable investment in basic skills programs has also been made. As indicated in a Department of Defense (DOD) study, during fiscal year 1979 approximately $56 million and an enrollment of 160,000 were allotted to basic-skills education.[5] The military has a high demand for listening, reading, writing, and arithmetic skills. Reading levels of material, for example, average in the 10-13 grade level range. This far exceeds the reading skill levels of many military enlistees as well as much of the civilian youth population.

Thus, there are a variety of basic skills programs in DOD and the four services. Pre-enlistment programs, such as referral to civilian adult basic education and English as a second language (ESOL) programs, are sponsored by DOD for applicants who do not meet service enlistment requirements. All of the services have some form of basic-skills education available from the time the new recruit enters the service. One such program is the Air Force PLATO SIP (Skills Improvement Program), which uses CAI to improve the reading skills of medical personnel and the math skills of maintenance technicians.

Project FLIT. Project FLIT, a job-oriented, or functional literacy program, is being developed under Army support. Work on this program was started in 1967 and is ongoing. Military job literacy tasks are really quite different from reading skills applications practiced in traditional schools. For example, schools emphasize "reading to learn" while military job tasks involve "reading to do" (e.g., finding specific information or following directions). While schools test memory for what is read with closed book tests, military job tasks are generally performed in the presence of the written material, which is consulted frequently.

Researchers attempted to estimate the actual literacy demands of military jobs. One product of this research was the FORECAST readability formula, which was developed using Army job reading material and an adult Army recruit population. Another product was a "Guidebook for the Development of Army Training Literature."[6] This manual attempted to help Army writers create performance-oriented training materials written at an appropriate level for Army readers and oriented to identified job reading tasks.

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[4] Adult Performance Level Project Staff, *Adult Functional Competency: A Summary* (Austin, Tex.: University of Texas, 1975).

[5] Defense Audit Service, *Report on the Review of Installation-Sponsored Education Programs for DOD Personnel* (Report No. 81-041, January 1981).

Project FLIT provides training in identified Army reading tasks using actual Army materials. It was extensively field tested and was found to result in gains in the performance of the job tasks trained. The ideas and techniques of the FLIT program were incorporated in a job-oriented reading program (JORP) for the Air Force, targeted at a different population and using different materials, a program also field tested with some success. Expansion of this program to include all "problem" job fields in the Air Force is being considered. The Navy JOBS program, a remedial program designed to prepare motivated, but otherwise ineligible, people for technical training is also a product of this technology. An additional product is a prototype job reader's task test developed for the Army and now being modified and reformed.

PREST Program. In the future, the services may be forced to enlist a greater number of marginally qualified recruits because of manpower shortages. In response to this, the Navy is expanding its Academic Remedial Training (ART). The Chief of Naval Education and Training contracted for the development and testing of a computer-based approach known as the Performance-Related Enabling Skills Training (PREST) program. PREST involves on-line reading and study skills instruction via the PLATO system, augmented by Navy-related off-line drill and practice. An automated system such as this was thought to be an attractive alternative to increasing the number of instructors.

A 1980 cost analysis showed the automated program to be less cost effective than increasing the number of military instructors. The usage charge for PLATO with its centralized mainframe was found to be the chief reason. This difference in cost should, however, steadily decline in future years. Advances in computer technology will make stand-alone systems more attractive economically than the centralized mainframe for this type of fixed instruction. In addition to project PREST, Navy R&D efforts are under way to examine the feasibility of teaching phonics by a computer-driven voice synthesizer. If this is successful, there are plans to computerize vocabulary development, reading comprehension, and study skills.[7]

Simulation Programs

Flight training simulations are extremely varied in scope, purpose, and fidelity of realism. They save expense and training time because the simulator can be repositioned to some starting point in flight without taking the actual time and fuel to fly there. Moreover, simulators provide the opportunity to interrupt the flight at any point to give the student immediate feedback on particular aspects of pilot performance. Finally, the simulator can be used for training in emergency maneuvers that are inherently dangerous to actually attempt.

In 1970, the U.S. Air Force Human Resources Laboratory's Advanced Systems Division contracted with the Singer Co. to build the most sophisticated flight simulator yet devised, the Advanced Simulator for Pilot Training (ASPT). Unlike other simulators, it was intended for research as well as for flight training, giving it a multipurpose potential for transference of research results to the civilian sector.

The Army Research Institute for the Behavioral and Social Sciences (ARI) is engaged in the development of computer-assisted simulation of tactical communications as part of an overall effort in the area of simulation-based training systems. This effort will provide the Army with the capability to simulate battlefield communications between leaders in the field and support personnel, such as artillery fire direction controllers, and the superior and subordinate commanders. Battlefield communications are typically very structured and stereotyped. For instance, the exchanges between an artillery forward observer in the field and the fire direction controller are specified in Army regulations.

Training simulations are used to replicate many military situations—from tank driving to elaborate ship docking. The Army tank driver simulators are fully automatic and include audiovisual as well as motion cues. Such devices simulate malfunctions such as brake failure or engine shutdown. Many of these procedures and malfunctions appear more than once throughout the programs, and thus allow for repeated practice. The device also simulates such activities as driving up hills and over obstacles.

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[6] R. P. Kern, T. G. Sticht, D. Weltz, and R. N. Hanke, *Guidebook for the Development of Army Training Literature* (Arlington, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, November 1976).

[7] R. A. Wisher, *Computer-Assisted Literacy Instruction in Phonics* (NPRDC TR 80-21) San Diego, Calif.: Navy Personnel Research, May 1981.

In maintenance simulation, the Navy through the NPRDC is developing an Electronic Equipment Maintenance System that will simulate electronic receiver and radar systems, using a microprocessor. This system shows promise in facilitating the management of troubleshooting problems through electronic equipment. NPRDC has also developed a program that teaches how to solve dynamic problems involving the variational analysis of current flow in complex electronic circuits.

The interchangability of technology transfer is demonstrated through the Army's adaptation of a commercial coin-operated game by Atari called "Battlezone" to train tank operators. "Battlezone" is a three-dimensional war game in which the operator moves around the battlefield at will and shoots at targets as they appear. Because the game is very realistic, trainees' reflexes and operating skills are improved with practice. Atari has redesigned the keyboard to mimic an actual control panel and realistically simulate the actions of a tank.

Video Disks in Military Training

The military services, particularly the Army, have been very active in video disk research. Most of this work has been initiated or coordinated by the Army Communicative Technology Office (ACTO) at Fort Eustis, Va. ACTO's mission is to get the Army "off paper" and into electronic media for storage and communication. Both the Defense Advanced Research Projects Agency (DARPA) and ARI have also supported a number of video disk research projects for training purposes.

One of the first ACTO projects was a "Call for Fire" disk that demonstrated the potential of video disk for packaging multimedia self-study training materials. This disk involved a specially designed computer-controlled video disk system. A number of different existing training materials (field manuals, training extension course lessons, video tapes, films, and skill qualification tests) used to train forward observer skills were integrated on a single video disk, a good illustration of the economy of video disk storage. Cost studies conducted for ACTO around this integrated training package indicated that it would result in savings over the existing materials on the basis of reductions in duplication and distribution costs alone.

A second innovative use is the SIDE (Soldier Information Delivery Equipment) project, which involves the use of video disk for tank turret maintenance training. This project utilizes a computer-controlled video disk system called TMIS (Training Management Information System). Video disk is used to store the contents of a large volume (that is, thousands of pages) of maintenance manuals and skill performance aids. By means of a 5-inch cathode ray display tube connected by cable to the TMIS computer/video disk station, soldiers are able to use the system while actually doing maintenance inside a tank. With their electronic maintenance manuals, the trainees have more information at their fingertips than would normally be possible in the confined space of a tank turret.

A third innovative project is the use of video disk for a satellite communications ground station repair course (MOS 26Y10) at the U.S. Army Signal Center, Fort Gordon, Ga.[8] The satellite communications equipment needed for the course costs about $12 million, and each repair involves $200 to $2,000 worth of parts. There is a great need to minimize equipment usage by unskilled students wherever possible. The video disk provides low-cost hands-on equipment and repair practice without using the actual equipment or parts. A lightpen is used by students to identify switches, select switch positions, plug in jacks, or indicate faulty parts to be replaced. In addition to reducing the need for actual equipment, it is now possible to measure student performance in accuracy or speed and to provide feedback while the student is learning.

Yet another innovative effort is the Video Disk Interpersonal Skills Training and Assessment (VISTA) project at Fort Benning, Ga. VISTA involves the study of interactive video disk for leadership training and assessment. It is used in a two-screen paradigm to present conflict scenarios that might arise between an officer and a subordinate. The officer trainee or candidate is first presented with a dynamic, visually simulated situation, including the initial remark of the subordinate on the screen. The trainee must select a response with the lightpen from four options presented visually on the screen control. The trainee then sees the subordinate's reaction to this response on the color monitor.

The disk features two modes: an experimental mode in which the interaction simply proceeds on the basis of the responses and a pedagogical mode in which feedback is immediately provided on the appropriateness of the response selected. A total of eight disks are planned that will provide over

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[8] W. D. Ketner, "The Video Disk/Microcomputer for Training," *Training and Development Journal*, May 1981.

100 leadership scenarios. A major use of these disks is seen to be an effective, objective, and inexpensive assessment of officer candidates.[9]

A number of other application areas are being explored by the Army. One area is the use of video disk for recruiting. The Joint Optical Information Service (JOINS) allows local recruiters to show visually what type of duties and training are associated with a specific military occupational specialty (MOS). Currently, some 30 MOSs are available on JOINS.[10] In the equipment simulation areas, WICAT, Inc. has developed an electronics troubleshooting video disk for the Hawk missile system. Perceptronics Inc. has developed a video disk-based simulation for the M6O tank gunnery training. Both of these projects were supported by DARPA.

A number of video disk projects are also under way in the basic skills area. The U.S. Army Europe is supporting the development of functional literacy instruction using a particular job category (MOS 63, Vehicle Maintenance) as a focus. Also, DARPA is exploring the use of the video disk-based Spatial Data Management System (SDMS), originally developed at the Massachusetts Institute of Technology for training in various life-coping skill areas (e.g., spatial orientation, study skills, listening).

In addition to these application projects, which have resulted in the development of actual video disks, the Army and DOD have supported research projects that explore theoretical or procedural aspects of the technology. For example, ARI has supported studies of how video disk relates to the standard instructional system development methods used to develop training materials in the military. The Navy supported an early study of video disk authoring approaches.[11] ACTO has supported research on the electronic conversion of print media to video disk and the optional presentation features for electronic delivery systems. (See table A-7 for a summary of these applications.)

These research projects have all involved interaction between a number of different Army/DOD agencies and contractors. They have also involved a variety of different hardware configurations. It is noteworthy that all of the video disk applications discussed have involved externally programed interactive capability. Although the Army has conducted a few projects with manual and internally programed interactive video disks (not discussed here), it appears that the Army believes the type of interactive capability provided by external microcomputer control is necessary for the instructional applications involved in military training. In contrast, industrial training applications have focused on the manual and internally programed level of interactive video disks, possibly because industry cannot afford the greater costs of an externally controlled system.

Direct To The Home

All of the information technologies currently used by schools, the military, libraries, museums, and industry can also be used in the home. The increasing availability of these technologies coupled with their rapidly declining cost, presents a unique opportunity for learning in the home. While most of the present applications have been directed at a specific age group, the focus is now shifting to provide programs for more diverse populations.

Table A-7.—Summary of Military Video Disk Projects

Project	Groups involved	Hardware involved (player, microcomputer)
Call for fire	ACTO/WICAT Inc.	Magnavox, Pascal MicroEngine (custom)
SIDE	ACTO/Hughes Aircraft	Thompson, Hughes (custom)
MOS 26410	ACTO/Signal School	DVA 7820, Apple II
VISTA	ARI/ACTO/TDI Litton-Mellonics	DVA 7820, Apple II
JOINS	ACTO/Recruiting Cmd.	DVA 7820, Apple II
IHAWK	DARPA/WICAT Inc.	DVA 7820, Pascal MicroEngine (custom)
LCP-I	ARI/Perceptronics Inc.	DVA 7820, ? (custom)
MOS 63	USAEUR/University Utah/ University Maryland	DVA 7820, Apple II
SDMS	ARI/DARPA/HumRRO	DVA 7820, Cromeco (custom)

SOURCE: Office of Technology Assessment.

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[9] F. N. Dyer, et al., "Interactive Video for Interpersonal Skills Training," 1981.

[10] J. Tice, "Video Disk Could Get Army 'Off Paper'," *Army Times*, Aug. 31, 1981, p. 14.

[11] H. D. Kribs, "Authoring Techniques for Interactive Video Disk," *Journal of Educational Technology Systems*, 8(3), 1980.

Findings

- There has been a dramatic increase of microprocessors, hand-held devices, and information services provided via cable or public television in the home.
- Educational products and services are increasingly being marketed directly to the home.
- In response to market forces, these educational products and services are targeted predominantly at professionals and families with relatively large disposable incomes.
- As with other educational markets, there is a need for materials that review and evaluate these products and services.

Adult Market

An estimated 37,000 to 73,000 adults participate in some sort of educational program. Adult programs are offered in a wide variety of institutional settings—in elementary and secondary schools, universities, private institutions, businesses, libraries, and museums. Adults, the fastest growing segment of American society, represent a potentially large sector, of the educational market. However, while many adults might benefit from continuing education, a large proportion of them have, as yet, remained uninvolved.

Apart from their number, there are several reasons why adults might be expected to constitute a growing sector of the educational market:

- Approximately one-third of all American adults are changing or considering changing their careers and realize the need for additional education.
- More and more States require additional educational programs for professionals; e.g., for recertification of physicians. Continuing education has become one condition for license renewal in many areas.
- Within certain fields, education requirements are being upgraded, increasing the need for continued education.[1]

Adult participation in instructional activities has been limited by situational, dispositional, and institutional factors. Situational barriers are, for example, lack of money, insufficient time because of job and home responsibilities, lack of child care, and lack of transportation. Attitudes and self-perceptions form the basis of dispositional barriers. Thus, an aged person may feel incapable of learning or a high school dropout may feel inadequately prepared in basic knowledge to do well in another formal instructional setting. Institutional barriers are exemplified by high tuition charges, inconvenient scheduling of courses, and the lack of student services geared to adult needs. Educational services delivered directly to the home via both existing and new technologies may overcome many of these barriers.[2]

Instructional Television

In an innovative effort to capture this expanding market, 600 colleges and universities in cooperation with the Public Broadcasting Service (PBS) provide college courses for credit via local public service stations. These courses are aired nationally by over 200 stations (80 percent of the public TV stations). Although institutions and stations can choose from up to nine programs, most offer two per semester. In the fall of 1981, enrollments exceeded 20,000. An increase was expected for the spring semester.

Recognizing the large, virtually untapped home market, PBS has already designed courses for the undergraduate student, and, in the near future, plans to provide informal learning courses as well as professional and career development programs. Current courses, such as "The American Short Story" and "Personal Finance and Money Management," are of both general and professional interest. Colleges and universities participating in the program provide materials and counselors on campus, and give midterm and final examinations. They pay PBS a licensing fee and a small charge per student enrolled. The student pays approximately $150 per course, which covers materials.[3]

PBS is not alone in providing educational services via television. Community colleges such as those in the Coast Community College District, Dallas Community College District, and Miami-Dade Community College District have also been actively involved in instructional television endeavors. Cable television companies also supply educational materials nationwide. Columbia Cablevision of Westchester Inc., and Qube, in Columbus, Ohio, offer courses with an interactive capability that allow students in the home to answer questions posed by the instructor in the classroom. Qube (Warner Amex) currently has 50,000 subscribers, approximately 34,000 of whom receive its interactive programs.[4] This company offers courses for credit from four institutions: Ohio State University, Capital University, Columbus Technical Institute, and Franklin Institute. Because of its interactive capabilities, the Qube system is educationally unique.

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[1] Public Broadcasting Service, "Program Service, Section IV, Exhibit P-1," Washington, D.C., Jan. 6, 1982.

[2] C. Dede, *Potential Clients for Educational Services Delivered by Information Technology*, contractor report to OTA, March 1981.

[3] Public Broadcasting Service, PTV-3/Adult Programing Department, *Background Paper on the Partnership Between Public Television and Higher Education to Deliver Adult Learning Courses*, Washington, D.C., n.d.; and Public Broadcasting Service, *Adult Learning Programing Schedule Fact Sheet for Colleges and Universities for Fall 1981*, Washington, D.C., n.d.

A proposal that could greatly expand educational services in the home is now under consideration by PBS. The proposed "National Narrowcast Service" would establish a resource to nationally distribute educational, professional training, cultural, and information video materials. This service would also alter the local PBS stations' role, transforming them into local telecommunications centers. Using a satellite distribution system to interconnect local PBS stations, and Instructional Television Fixed Service (ITFS)* to connect the stations, colleges, and other users, programing in the following areas would be available:

> Training material in special skills; safety programs; material designed for rehabilitation of the aged, infirm, or mentally disturbed; clinical studies; new arts and crafts; material intended to keep professional and semi-professional people abreast of the state-of-the-art in various fields; in-service training for teachers; instructional material for purposes of entertainment or cultural advancement.[5]

Multimedia Instruction

The School of Management and Strategic Studies of the Western Behavioral Sciences Institute offers a management program that relies heavily on information technology. The program is designed for executives in the private and public sectors (Federal and nonprofit). Following a short study program in LaJolla, Calif., participants continue their studies via on-line services, telephone conversations, teleconferencing, and electronic mail. The terminals and other equipment are included in the cost of tuition and are retained by the user at the conclusion of the formal program. Participants install the technology in their homes or offices. This approach has a number of benefits: the participants continue to work for their sponsoring organization throughout the course of study (thus, no work time is lost); information gained from the program can be employed immediately in a working environment; the users become familiar with the technology, which is not usually the case for most higher level executives; and users are networking with both members of the program and with others following completion of the program.[6]

Electronic Learning Devices

Approximately 18 million electronic devices—microprocessor games such as "electronic baseball" and hand-held devices such as Speak and Spell—were sold between 1979 and 1980. Typically, the price for these games ranges from $10 to $3,000, the cost of a microcomputer. Users of these devices can be as young as four, or they can be adults. The growth of this market has been rapid and impressive. Although these games and learning devices were not introduced until the mid to late 1970's, there are a vast number on the market. While OTA has made no attempt to evaluate their effectiveness—and particularly the effectiveness of those designed for learning, their uses in the home will be briefly described.

Given the relatively low cost of production and a growing desire by parents for enhanced educational services, the market for microprocessor games has grown so fast that some major manufacturers been unable to keep up with it. Sales of nonvideo electronic games have skyrocketed from $20 million in 1977 to $1 billion in 1980.[7] The experience of Texas Instruments in the home market provides some insight into the development of learning technologies. One of the early leaders in this field, Texas Instruments originally sought to develop a market in schools and not in the home. Their first product was a Texas Instrument calculator accompanied by a package of instructional materials that was designed to assist teachers and students in the classroom. With it the company hoped to demonstrate the use of the calculator as a learning device. Although this initial package was unsuccessful, it led the company to focus on the home market and to market directly to the individual consumer. Their next product, Little Professor, was a hand-held device that provides a series of mathematical problems and answers designed to become increasingly difficult. Since the introduction of Little Professor, Texas Instruments has developed and successfully marketed several similar games. One of these, Speak and Spell, differs from earlier games in that it has a synthesized voice that helps the user to spell.

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[4] LINK, *Survey of Selected U.S. Videotex/Two-Way CATV/Teletext Operations* (New York: LINK, June 15, 1981).

*ITFS is a short range multiple distribution technology allowing for an unlimited number of users in a specific area. PBS is proposing the use of four ITFS channels in each community served by a public service station.

[5] Public Broadcasting Service, op. cit., 1982.

[6] TALMIS Conferences, Chicago, Ill., Feb. 18-19, 1982.

[7] "Newest Trends in Toys," *Ebony Magazine*, November 1980.

Other manufacturers have also introduced mathematical games—e.g., National Semiconductor's Quiz Kid. There are also other kinds of hand-held learning devices such as Coleco's Quiz Wiz, a multiple-choice game which asks and provides answers to 1,001 questions on a wide variety of subjects such as sports, movies, television, and history.

Video Disk

Since the video disk is relatively new, there are very few examples that demonstrate its educational applications in the home. Disks that are available for school use are, however, equally applicable for use in the home. Some examples of these are the films of Jacques Cousteau, the National Gallery's art masterpieces, movies such as "Tom Sawyer" or "Better Tennis in 30 Minutes."

The first video disk designed specifically for children, the "First National Kiddisc," is an interactive video disk produced by Optical Programing Associates. It allows for individually paced instruction. Games on this disk include The Flag Game, in which the user identifies national flags, and A Trip to the Zoo, by which the child can learn to identify 40 animals. Another section of the disk uses the unique two-channel audio available on the video disk players to explain pig latin. On one channel, a child on camera explains in pig latin how to speak pig latin; on the other channel there is a voice-over translation. In a section on sign language, the manual alphabet is taught by showing the sequence in slow motion.

Publishers of educational materials and others are currently planning new video disk projects. Walt Disney Production, Children's Television Workshop, and Scholastic Productions as well as encyclopedia publishers are among those who plan to utilize this new technology.

In addition, Arete Publishing in cooperation with the International Institute for Applied Technology (IIAT) has produced an experimental interactive optical video disk with information from Arete's *American Academic Encyclopedia*. Sound and films were added to articles and illustrations chosen from the encyclopedia. The more than 20 segments on the video disk demonstrate the capabilities of the technology. Starting from a general section on the species of dinosaurs, a user may branch off to find more information about a specific type of dinosaur. The segment on Ludwig von Beethoven presents his biography, illustrations of his life and musical scores, and musical segments from the composer's works. Designed to be experimental, this disk does not yet cover all 21 volumes of the encylopedia, although ARETE hopes to put the entire encyclopedia on disk in the future. Still in the research and development phase, these disks are not commercially available for use in the home. When they come on the market, each disk will cost about $500. After purchasing a disk, each year the consumer can exchange it for an updated version for about $100.[8]

Impacts of Information Technology

Of all the information technologies available for the home, the personal computer is the one that is expected to have the greatest use and for which there is expected to be the largest and fastest growing market. Furthermore, the microcomputer, in conjunction with other technologies such as the video disk or two-way interactive cable, appears to have the greatest potential for home use.

With the increasing use of microcomputers in the home, the educational applications are growing at a fast pace. The personal computer market was estimated to be a $1.5 billion to $2 billion industry in 1981. One recent figure notes that the home market accounts for over $100 million in sales of both hardware and software.[9] The number of personal computers purchased between 1977 and 1980 was estimated at around 1 million, and a similar figure was estimated for sales in 1981. Sales are expected to increase substantially for several reasons: greater exposure to the technology in the schools or in business, the introduction of cable services, the availability of information resources such as The Source and Dow Jones/Retrieval Service, the development of more consumer-oriented software, and the declining cost of the microcomputer.[10] Also, manufacturers will be actively marketing their equipment to the consumer.

Together, these factors will lead to a serge in the market. Microcomputers are now available for as little as $100. At this price, the microcomputer can be used for games or simply to familiarize the user with the technology. Advertising emphasizing the educational applications in the home has increased enormously. In fact, these commercials recall the earlier ones of the encyclopedia salesmen, their sales pitch being that the microcomputer will assist the student in school.[11] Moreover, the proliferation of computer stores and the retailing of the technology through department stores and the like has given rise to increased purchases. For example, Texas Instruments plans to sell their microcomputers through national chain stores such as J. C. Penney.

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[8] LINK, *Optical Videodisc Applications* (New York: LINK, NRM, vol. 3, No. 1, First Quarter, 1982).

[9] B. Isgur, W. Paine, and H. Mitchell, personal communications, January 1982.

[10] LINK, *Using Personal Computers* (New York: LINK, NRR, vol. 3, No. 1, Second Quarter, 1982).

The growing diversity of home applications such as gaming and word processing, and the development of financial and statistical packages such as Visicalc and others appeal to a wide range of users. One indication of this is the formation of a large number of computer clubs. All of the clubs swap hardware and software information. Some provide training sessions; some are affiliated with a specific manufacturer (e.g., Crab Apples and Crab Polishers); and some are directed at specific interests (e.g., Theater Computer Users in Dallas, Tex., and the Behavioral Sciences Specialists in Murfreesboro, Tenn.[12]

There are hundreds of software packages available to assist students in all grades and age groups in many subjects such as mathematics, the sciences, reading, writing, and spelling. The rapid expansion of the personal computer market should result in a greatly increased volume of educational software together with a demand for evaluative materials. As in all other markets for educational software, there has been very little evaluation of new software. While there are catalogs for consumers, there are few reviews of most educational packages. Users must depend for their evaluations on a limited number of sources: computer newsletters, computer magazines, an underground network, and the few computer manufacturers who have begun to produce evaluative reports.

Many analysts believe that the market for home and business microcomputers will be driven by the need to use the technology to retrieve information and to perform transactions. The technology allows a user to connect to on-line data bases and other services via a modem, a device that connects the microcomputer to a telephone line. Home users can now connect to services such as The Source, CompuServe, the Dow Jones News/Retrieval Service, and others. The Source, available through Telenet and Tymnet packet switch networks, offers games, electronic mail, news, the "electronic college," and other services. The college, although limited to three courses this year, plans to expand its listings within the next few years. CompuServe, very similar to The Source, acts with the Associated Press as the system operator for 13 U.S. newspapers in an experiment of electronic newspaper delivery. Viewtron, a videotex experiment in Coral Gables, Fla., offered slightly different services to home users. Knight-Ridder Newspapers and AT&T sponsored news, shopping, travel, banking, games, learning aids, consumer advice, and more to over 700 sites via modified television sets. Similarly, Cox Cable Communications is developing INDAX for use by its cable franchises.[13]

The introduction of cable services in the home will give rise to a large number of new educational projects. An estimated 28 percent of the homes in the United States are wired for cable. It is predicted that 38 percent will be wired by 1985 and 50 percent by 1990.[14] Educational services such as those provided by Cox Cable, Qube, and others are expected to grow quickly.

Information Technology and Special Education

Technologies that are now being developed may offer great benefits to individuals that require special educational services—a group that includes the gifted and those with learning, physical, and emotional disabilities. Since special education is a field, and not an institution, OTA did not fully explore the uses, impact, and effects of these technologies on special educational services. However, because the technologies will have a considerable effect on schools overall, OTA examined some of their applications for the gifted and handicapped.

Findings

- Providing educational services for students with special needs is costly and requires more effort than providing for students in general.
- Information technologies will be particularly valuable to students with special needs because they will reduce the cost of their education and they will provide them self-paced, individualized instruction.
- Using information technology could ease the financial and resource burdens placed on the

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[11] A. Pollack, "Price Decline Spurs Sales," *New York Times*, June 17, 1982, pp. D1,6.

[12] LINK, op. cit., 1982.

[13] LINK, op. cit., 1982.

[14] LINK Executive Conference, New York City, May 26, 1982.

schools by laws mandating education for the gifted and handicapped.

- The overall cost of R&D to address the specific needs of this diverse group is very high, and in some instances, even prohibitive. Each disability may require a unique technological application. It has been suggested that increased Federal funding is merited to support the R&D efforts needed to encourage the marketing of these technological applications.
- Although a number of technological applications to help handicapped persons are available, they have not been marketed because they are too costly.
- Information technologies can help train many handicapped persons for productive work.

Information technologies may offer greater benefits to the gifted and the handicapped than to any other segment of the education market. These students benefit from specialized individualization, a capability of many emerging instructional technologies. For example, computer programs can be designed to translate written material into speech that is understandable to the blind, or to instruct retarded children on a step-by-step basis. Overall, such capabilities can help to make handicapped people more independent. Other types of programs can help maximize the abilities of gifted students. Recognition of the special needs of these two groups have led to the passage of two laws—Public Law 142 and Public Law 80-313. These laws require that, using formula grants and preschool incentive grants, handicapped and gifted children be provided with special services to be funded in part by the Federal Government.

Information technologies have several attributes that make them particularly useful for addressing the special needs of gifted and handicapped students.[1] Because their individual situations vary significantly from case to case, these students most often need to have individualized instruction that can best be provided by highly specialized personnel. Thus, their education is generally labor intensive, and very costly. The new information technologies can provide self-paced and individualized instruction at a considerably lower cost.

The cost and difficulties entailed in developing these technologies may, however, preclude their widespread application. Although the overall population of gifted and handicapped students is statistically large, it is very small when measured in terms of individual disabilities or needs. When designed to meet the needs of a particular group, these technologies can be too costly to produce.[2] Moreover, the time required from their development to their production may take as long as 20 years.[3] For these reasons, it has often been proposed that the Federal Government provide support for research and development in this area.

Technology for Administration

The use of information technology to administer special education programs is only now in the process of being developed, tested, and evaluated. There is a large potential for data management applications in this field, particularly given the requirement that each student participate in Individualized Education Programs (IEP). An IEP defines a student's disability(ies) and appropriate education program. This exercise is a very time-consuming process that could be greatly facilitated by the judicious use of information technology. Computerized diagnostic models are now being developed. One model, developed by Columbia Learning Systems, generates a computerized IEP based on diagnostic information supplied by specialists. It contains information about student needs, their areas of deficiencies and suggested ideas and material for remedying them. It also monitors the student's progress. Other programs such as these are becoming more and more common.[4]

The development of diagnostic remedial information technology procedures is relatively new in the United States. This type of program tracks students to discover their strengths and weaknesses in specific skills and how they relate to a student's approach to a specific problem. This information can then be used to determine a course of remedial action. Most diagnostic models are for mathematics.[5]

Information technologies can also be used to schedule the handicapped in specialized working or instructional groups using criteria such as instructional needs, st[illegible] mic levels, staffing requirements, and [illegible] of staff and space.[6]

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[1] C. Dede, *Potential Clients for Educational Services Delivered by Information Technology*, contractor report to OTA, March 1981.

[2] V. W. Stern and M. R. Redden, *Draft Case Study of Selected Telecommunication Devices for the Deaf*, contractor report to OTA, December 1981. Much of the work done to develop teletypewriters for the deaf was done on a volunteer basis, donated by handicapped or concerned individuals. The present rapid advances in information technology, along with declining costs, may reduce this developmental time.

[3] Ibid., p. 11.

[4] M. Lindsey, *State-of-the-Art Report; Computers and the Handicapped* (Medford, Oreg.: Northwest Regional Educational Laboratory, August 1981), p. 133. There is, for example, the Organized Resource Bank of IEP Text (ORBIT), and Programing for Individualized Education (PIE).

[5] Ibid., p. 133.

Technology As [illegible]hetic Devices

By enabling handicapped persons to speak through video and speech synthesizers, some information systems can serve as prosthetic devices. For example, the Total Talk Full Speech Computer Terminal, developed by Maryland Computer Services, converts computer-transmitted data and information into synthetic speech. The system has an unlimited vocabulary. It uses rules for enunciation, and inflection for clarity. Total Talk, which costs around $6,000, can provide two-way information. Similar devices, the VS-6 and ML-1 voice synthesizers, developed by the Votrax Division of Federal Screw Works, produce electronically synthesized speech from a low-speed, digital input. Both of these systems are designed for persons with visual impairments, and both enable the users to work in the areas of computer programing, information processing, and information retrieval.

Many such projects have been successfully introduced through joint efforts between the Federal Government and the private sector. One example is the caption decoder, developed under the sponsorship of the Department of Health, Education, and Welfare (now the Department of Education), the Corporation for Public Broadcasting, the National Broadcasting Co., and the American Broadcasting Co. When attached to a television set, these decoders allow deaf viewers to see captions on selected networks and programs. Costing $269, they are available through Sears, Roebuck, & Co.[7]

Another example is Optacon. This device, designed for the blind, produces images of printed letters using small, raised, vibrating wires. With one hand the user guides the pick-up along the printed page, while the fingers of the other hand detect the images on a stationary device. The Kurzweil Reader, also developed for use by the blind, "reads" a page of text aloud, using electronic voice synthesis. For these projects, Federal funds were invested in the R&D efforts as well as in purchasing equipment for the users.[8]

Technology As Instructional Aids

Information technologies have many applications as instructional aids. CAI, for instance, is used for a number of different handicaps or disabilities. Early use of CAI for the deaf began at the Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University. Assessments of this work with CAI show general increases in the mathematical skills of 3,000 deaf students. Nonspeaking autistic children have also benefited from the use of CAI. Having witnessed a display of 1,000 different audiovisual experiences on a television-like screen, 13 out of 17 children began to use some level of speech. The effectiveness of using a computer to teach extremely mentally retarded children was also demonstrated, when substantial gains were noted in the reading ability of 40 children.

In Chicago, students with hearing, visual, mental, or other learning disabilities have participated in a project sponsored by the South Metropolitan Association for Low Incidence Handicapped. The project used CAI programs—in math, reading, and the language arts—that were prepared by the Computer Curriculum Corp. Although evaluations are still underway, student progress has correlated with the amount of on-line access to programs.

In an ongoing study at Utah State University's Exceptional Child Center, computer and video disks are used with the mentally handicapped. The technologies allow for self-paced and individualized instruction. The project programs focus on discrimination between sizes, shapes, and colors; on telling time; on identification of functional words; and on the identification of colors. If successful, this project will not only assist mentally handicapped nonreaders but also those with other disabilities.[9]

To "encourage research in devising methods to assist handicapped individuals," NSF and Radio Shack sponsored a contest in the fall of 1981. Its purpose was to "create a partnership between personal computing and the rehabilitation, educational, and handicapped communities."[10] There were 900 entries in the contest. A few sample projects were:

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[6] Ibid., p. 134.

[7] Department of Education, *The Historical Role of the U.S. Department of Education in Applying Electronic Technology to Education* (Washington, D.C.: Department of Education, February 1981).

[8] Ibid.

[9] R. Throkildson, W. K. Bickel and J. G. Williams, "A Microcomputer/Videodisc CAI System for the Moderately Mentally Retarded," *Journal of Special Education Technology*, vol. II, No. 3, spring 1979.

[10] "Prizes Awarded in Search for Microcomputer Applications to Aid Handicapped People," *Electronic Learning*, vol. 1, No. 3, January/February 1982, p. 12.

- A pocket-sized computer to assist deaf people to communicate over telephone lines—a Radio Shack pocket computer with a coupler and a miniprinter.
- An "Eye Tracker" to aid severely handicapped individuals to express words via an infrared camera and a computer. The camera notes the position of the user's eyes with a specific word and the computer "speaks" the word.
- A computer that teaches deaf children to read lips by outlining lips, mouth, and tongue on a screen and then moving them to pronounce words.

The entries in the contest used off-the-shelf technology. Most of the projects could be made available immediately and would be of some use to a disabled person. The contest demonstrated that there is no immediate need for extensive R&D. What is needed instead is a way of identifying and encouraging the reformating of the technology to address the diverse needs of the handicapped population.

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Office of Technology Assessment

The Office of Technology Assessment (OTA) was created in 1972 as an analytical arm of Congress. OTA's basic function is to help legislative policymakers anticipate and plan for the consequences of technological changes and to examine the many ways, expected and unexpected, in which technology affects people's lives. The assessment of technology calls for exploration of the physical, biological, economic, social, and political impacts which can result from applications of scientific knowledge. OTA provides Congress with independent and timely information about the potential effects—both beneficial and harmful—of technological applications.

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